International Geology Review

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PARTIAL CONTENTS

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The editors of International Geology Review will give consideration to full English translations, condensations, and reviews submitted voluntarily for publication. Translators will be appropriately credited.

Readers are invited to direct to the editors their comments and discussions of articles published in the International Geology Review. Readers are encouraged also to submit suggestions as to published foreign literature considered worthy of translation and publication. Such suggestions should relate to materials of broad, general interest, rather than materials of limited reader interest.

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Vol. 3, No. 10 October 1961

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IGR TRANSLITERATION OF RUSSIAN

The AGI Translation Office has adopted the Cyrillic transliteration recommended by the U. S. Department of the Interior, Board on Geographic Names, Washington, D.C.

Alphabet		transliteration
А	а	a
Б	б	b
В	в	v
Г	г	g
Д	д	d
Е	е	e, ye (1)
Ё	ё	ë, yë
Ж	ж	zh
З	з	z
И	и	i
Й	й	y
К	к	k
Л	л	l
М	м	m
Н	н	n
О	о	o
П	п	p
Р	р	r
С	с	s
Т	т	t
У	у	u
Ф	ф	f
Х	х	kh
Ц	ц	ts
Ч	ч	ch
Ш	ш	sh
Щ	щ	shch
Ъ	ъ	"
Ы	ы	y
Ь	ь	'
Э	э	e
Ю	ю	yu
Я	я	ya

NOTES:

(1) "ye" initially, after vowels, and after ъ, ь; "e" elsewhere; when written as "ё" in Russian, transliterate as "yë" or "ë".

Well-known place and personal names that have wide acceptance will be used. Some translations may include elements of previous German transliteration from the Russian; this occurs in IGR most commonly in maps and lists of references. The reader's attention is called to the following variations between German and English systems which may cause confusion when trying to check back to original Russian sources.

German	English
w	v
s	z
ch	kh
tz	ts
tsch	ch
sch	sh
schtsch	shch
ja	ya
ju	yu

SOVETSKAYA GEOLOGIYA (SOVIET GEOLOGY) IN TRANSLATION, 1960, NUMBERS 1, 2, 3

CONTENTS, CRITIQUE, SELECTED PUBLICATION, AVAILABILITY OF TRANSLATIONS

The translation program of the American Geological Institute now includes complete translation of the journal Sovetskaya Geologiya (Soviet Geology), beginning with the 1960 volume year. Each issue is translated cover-to-cover. The translated papers are reviewed by members of the staff of the Geology Department of the Virginia Polytechnic Institute under an arrangement with Professor Byron N. Cooper, Chairman. Papers of greatest significance and most general interest undergo additional editing and are published in full in International Geology Review. All other papers, not selected by the review group for publication in IGR, are available as individual translations, reproduced in photocopy form from the translation manuscript.

The table of contents of translated issues of Sovetskaya Geologiya will be listed in this and subsequent issues of International Geology Review, showing author, title, original journal pagination, and reviewers' comments of each paper not selected for publication. Those papers appearing in IGR in full are designated by a star (★).

Orders for photocopies of translations not published in IGR should include the following information from the table of contents: Senior author, number of pages, price, and order reference number, i. e., "Nekrasov, 32 pp., $4. 80, Order ref:SG60-1-2." Payment must accompany order. Send to: Translations Office, American Geological Institute, 2101 Constitution Avenue, N. W., Washington 25, D. C.

Sovetskaya Geologiya (Soviet Geology) — January 1960, No. 1

CONTENTS AND TRANSLATION AVAILABILITY

Translation by Royer and Roger, Inc.

Antropov, P. Ya., TOWARD THE FURTHER IMPROVEMENT OF GEOLOGIC PROSPECTING.
pp.3-9 — Photocopy 12pp. $1.80, Order ref:SG60-1-1

Suggestions for improving efficiency of prospecting and development. Writer bemoans the lack of coordination and lack of utilization of well trained geologists in actual mining companies where they can efficiently help the development of the mine. Contains much propaganda.

★Kasatkin, D.P., THE STRUCTURE OF THE BASEMENT OF NORTHERN TURKMENIA AND KARAKALPAKIA ACCORDING TO THE RESULTS OF GEOPHYSICAL INVESTIGATIONS.
pp.10-33 — IGR, v.3, no,10 (this issue)

Nekrasov, I. Ya., and D'yachenko, V.I., MAIN FEATURES OF THE GEOLOGIC STRUCTURE AND METALLOGENY OF THE LOWER INDIGIRKA ORE DISTRICT.
pp.34-50 — Photocopy 32pp. $4.80, Order ref:SG60-1-2

Good summary of the geology of the region but too long. It is interesting to note the continuous section between the Ordovician and Devonian. One can determine the systemic boundaries only by fauna. Big unconformity at base of Permian. Mainly a regional description of intrusive rocks, structure affecting them, their petrology, and the type of metals associated with them. The article is similar to what one might write if you described California in a similar light. Probably not broad enough in scope.

Khakhlov, V.A., STRATIGRAPHY OF THE NORIL'SK COAL BASIN.
pp. 51-56 — Photocopy 8pp. $1.20, Order ref:SG60-1-3

This brief report is of too localized nature to be worthy of republication. The author rambles considerably and does not present tersely the conclusions of his study. The paper is very short. Conciseness is absolutely necessary to present the type of information that he is attempting to summarize.

Nevskiy, V.A. THE MORPHOLOGY AND HISTORY OF FRACTURES IN SOME ORE DISTRICTS IN THE TIEN-SHAN.
pp.57-71. — Photocopy 25pp. $3.75, Order ref:SG60-1-4

Largely an analysis of the development of shear and tension faults. Includes gradation of one into the other and the fact that many shears are paralleled by tension cracks. Concludes that this is caused by the reorientation of stresses. Have alternate failure by horizontal compression followed by vertical compression. Nothing unique.

★Korotkov, G.V., A GENERAL ESTIMATE OF THE WORLD'S COAL RESOURCES.
pp.72-74. — IGR, v.3, no.10 (this issue)

Shcheglov, A.D., SOME PROBLEMS OF THE METALLOGENY OF THE SOUTHEASTERN TRANSBAYKAL.
pp.75-86 Photocopy 20pp. $3.00, Order ref:SG60-1-5

Concerns the distribution of rare metals Sn, W, and Mo with their tectonic, geochemical, and age environment. General sequence is W—Sn—Mo (in order of decreasing age) with respect to intrusives and differentiation. Have read similar things in English before. Not a bad paper actually but probably more limited in interest.

Marinov, N.A. and Fomin, V.M., HYDROGEOLOGIC INVESTIGATIONS IN SUPPORT OF AGRICULTURE.
pp. 87-93 Photocopy 12pp. $1.80, Order ref:SG60-1-6

Rambling report that never gets down to facts.

Glebovskiy, Yu.S., AEROMAGNETIC INVESTIGATIONS CARRIED OUT BY THE FIRST SOVIET ANTARCTIC EXPEDITION (IN EASTERN ANTARCTICA).
pp.94-115, Photocopy 32pp. $4.80, Order ref:SG60-1-7

Parts of this paper, especially the geology and geophysical findings, may be of interest to geologists interested in Antarctic geology. A large part is of a very general nature and can be found elsewhere.

Short Notes

Glazunova, A.Ye., SOME CONTROVERSIAL PROBLEMS OF THE STRATIGRAPHY OF THE CRETACEOUS DEPOSITS IN THE WESTERN SIBERIAN LOWLAND.
pp.116-121 Photocopy 13pp. $1.95, Order ref:SG60-1-8

Noteworthy summary an age determination of strata from fossils occurring in drill cores. It discusses relative and apparently conflicting faunal data. A pertinent note because its notes presence of many fossils of worldwide importance.

Miklukho-Maklay, A.D. and L'vov, K.A., ANCIENT (PRE-ORDOVICIAN) VOLCANIC ACTIVITY OF THE POLAR AND SUBPOLAR URALS AND ITS RELATED COPPER-ORE OCCURRENCES.
pp.121-123 Photocopy 5pp, $0.75, Order ref:SG60-1-9

Describes the occurrences of some copper mineralization in Cambrian volcanic rocks (greenstone types). Concludes should look more closely in this area. Reminds one of the copper in the Catoctin.

Moiseyenko, F.S., GEOLOGIC NATURE OF THE CENTRAL KAZAKHSTAN GRAVITATIONAL MINIMUM.
pp.123-126. Photocopy 7pp, $1.05, Order ref:SG60-1-10

A review, and of general nature. Nothing startling.

★Ginzburg, A.I. and Tolstikhina, M.M., CONCERNING THE NATURE OF THE ORGANIC MATTER IN THE LOWER CAMBRIAN LAMINARITES CLAYS.
pp.126-129 IGR, v.3, no.10 (this issue)

★Ryabukhin, G.Ye. and Nesterov, I.I., GEOTHERMAL DEEP-WELL LOGGING IN THE OMSK AREA.
pp. 129-134. IGR, v.3, no.10 (this issue)

Tanatar-Barash, Z.I., MINERAL INCLUSIONS IN THE LOWER CARBONIFEROUS COALS IN THE WESTERN DISTRICTS OF THE DONETS BASIN.
pp. 134-139. Photocopy 13pp. $1.95, Order ref:SG60-1-11

A good description petrography of the nonorganic components of coal and related rocks. No new theories or poorly derived conclusions. Just good description. Probably limited reader appeal.

★Tikhomirov, V.V. and Sofiano, T.A., FROM THE HISTORY OF GEOLOGICAL SCIENCES, ANNIVERSARIES FROM JULY TO DECEMBER 1959.
pp.140-146 IGR, v.3, no.10 (this issue)

Scientific Notes and News

Magak'yan, I.G., THE FIRST ALL-UNION VOLCANOLOGY MEETING.
pp.147-148 Photocopy 4pp. $0.60, Order ref:SG60-1-12

Not a scientific note; rather a rambling journalistic note of a scientific meeting.

RESOLUTION OF THE FIRST ALL-UNION VOLCANOLOGY MEETING.
pp. 148-150. Photocopy 6pp. $0.90, Order ref:SG60-1-13

Not of general interest. Merely reports on the volcanologists' desire to get more funds and equipment to spur volcanological work.

Sovetskaya Geologiya (Soviet Geology) February 1960, No.2

CONTENTS AND TRANSLATION AVAILABILITY
Translation by Research International Assoc.

Discussion of new discoveries in West Siberian plain, the largest valley in the world. Is underlain by Meso-Cenozoic rocks. An area of new important oölitic-type iron ore deposits. Kolpashevo iron ore, 100 x 200 km., Upper Cret. Ore is 10 to 12 m. av. thickness (up to 36 m.), 30 to 40% Fe; is separable magnetically after heating; depth of ore is 200-300 kmters; also three other ore beds. Many other iron deposits (mainly oölitic, leptochlorite, and siderite) are mentioned in connection with Paleocene. Eocene, etc., deposits (often continental or coastal plain-type). Upper Cret. bauxites as well as younger deposits are described. Several ages of formations are indicated. Also have Mn ores of Paleocene and Eocene age in continental deposits. All of the deposits of course are related to the geomorphology, weathering cycles, and tectonic history of the basin. Rather a good summary article on general geology and ore of this area.

Comprehensive report on a 1,200-meter succession of lacustrine, paludal and alluvial deposits and of biostratigraphic techniques used in establishing the framework of correlation with heavy emphasis on palynology. A little long, with overemphasis of minor details.

This extrapolates to an interpretation of Quaternary history of insufficiently detailed study of particle size distributions of terrace materials in one cross section of a river valley. The interpretative part basically fails to recognize the nature of stream sedimentation, and therefore the conclusions are based on poor geology.

A summary on genetic classification of iron ores including ferruginous quartzites, contact-metasomatic replacement deposits, and supergene products, in beds of Precambrian age in the western Azov Region.

Discussion of the type of placers (buried, uplifted, terraces, etc.) related to geomorphology, tectonics, etc. Mentions favorable areas for search. Article narrow in scope.

Ore localized in volcanic-sedimentary, somewhat metamorphosed sequence of Kultabarsky suite, Lower Devonian. Ore localized in crush zones and many relatively small faults are important. More extensive hydrothermal alteration along faults and the clarke of lead increases in the carbonate rocks. Cites need for more intense study of cross and intersecting faults. Sounds like Tintic area, crudely.

★Konnov, L.P., POTENTIAL FOR PROSPECTING AND EXPLORATION OF BAUXITE ORES.
pp.115-124 IGR, v.2, no.10, (this issue)

★Kuzhelov, G.K. and Krutikhovskaya, Z.A., FORMATION OF RESIDUAL MAGNETIZATION AND ITS DISTRIBUTION IN ROCKS.
pp.125-139 IGR, v.2, no.12, p.1017-1028

Short Notes

Popov, Yu. N., DISCOVERY OF LOWER TRIASSIC SEDIMENTS IN THE CHUKOT FOLDED ZONE.
pp.140-144 Photocopy 9pp. $0.60, Oder ref. SG60-2-7

Paper merely reports on discovery of Lower Triassic in a local area. Typical of many Russian scientific reports, it merely reports a find and undertakes no synthesis.

Khudoley, K.M., UPPER JURASSIC DEPOSITS IN THE SOUTHERN AND MIDDLE SIKHOTE-ALIN.
pp.141-144 Photocopy 9pp. $1.35, Order ref:SG60-2-8

Article reports on stratigraphy, faunal zones, and stages of the Jurassic at Sikhote-Alin. Either the translation of this article is inaccurate, or the author has not made his point. Limited reader interest.

Kratkovskiy, L.F., ERUPTION OF A MUD VOLCANO IN SAKHALIN.
pp. 145-146. Photocopy 3pp. $0.45, Order ref:SG60-2-9

Paper of minor reader interest.

Criticism and Review

Bogatskiy, V.V., REVIEW OF BOOK BY V.P. KAZAINOV "MESOZOIC AND CENOZOIC DEPOSITS IN WESTERN SIBERIA"
pp. 147-148. Photocopy 4pp. $0.60, Order ref:SG60-2-10

This is an opinion of a book, the thesis of which appears not to be the general Soviet viewpoint. However, insufficient review of the book's subject matter has been present so that an independent judgment can be made by an American reader.

Scientific Notes and News

Belyayevskiy, N.A., Vakhrameyev, V.A., Gorskiy, I.I., Nalivkin, D.V., Ovechkin, N.K., and Sokolov, B.S., SUMMARY OF THE ALL-CHINA STRATIGRAPHIC CONFERENCE (PEIPING, NOV. 13-21, 1959),
pp.149-160. Photocopy 34pp. $5.10, Order ref:SG60-2-11

Good summary of geologic provinces and stratigraphy of the Chinese Peoples Republic including many recent stratigraphic discoveries and report on status of knowledge about the various geologic systems.

Sovetskaya Geologiya (Soviet Geology) March 1960, No. 3

CONTENTS AND TRANSLATION AVAILABILITY
Translation by Royer and Roger, Inc.

Li Sy-huan, INTRODUCTORY ADDRESS AT THE ALL-CHINESE STRATIGRAPHIC CONFERENCE, IN PEIPING.
pp.3-8 Photocopy 9pp. $1.35, Order ref:SG60-3-1

Not much science, mainly a verbose account of what the Chinese Peoples Republic intends to do, heavily seasoned with propaganda.

Eyrish, L.V., NEW DATA ON PRECAMBRIAN AND PALEOZOIC GEOLOGY OF THE LESSER KHINGAN.
pp.9-16 Photocopy 12pp. $1.80, Order ref:SG60-3-2

This is strictly a regional report and would be of no interest to anyone not acquainted with area or adjacent ones and with a desire to correlate among them.

Leonov, G.P., CORRELATION OF PALEOCENE-LOWER EOCENE DEPOSITS ON THE RUSSIAN PLATFORM AND NORTH CAUCASUS.
pp.17-27 Photocopy 19pp. $2.85, Order ref:SG60-3-3

Good account of paleography of depositional basins in eastern Europe, based on analysis of faunas. Advocates three-fold division of the Paleocene.

★Sigov, A.P., STRATIGRAPHIC AND CORRELATION SIGNIFICANCE OF TERRIGENOUS COMPONENTS OF SEDIMENTARY ROCKS.
pp.28-39 IGR, v.3, no.10 (this issue)

Svyatlovskiy, A.F., ULTRABASICS OF KAMCHATKA AND THEIR POSITION IN THE TECTONIC PLAN OF THE PENINSULA
pp.40-47 Photocopy 14pp. $2.10, Order ref:SG60-3-4

Almost but not quite in the "top quarter" category. This translation would benefit from careful editing.

★Ginzburg, V.I. and Rogover, G.B., REGULARITIES IN THE DISTRIBUTION OF NONFERROUS AND PRECIOUS METALS IN PRINCIPAL ORE MINERALS AND SILICATES OF THE NORIL'SK DEPOSITS.
pp.48-60 IGR, v.3, no.10 (this issue)

Zak, S.I., PROBLEMS OF THE ORIGIN OF IGNEOUS ILMENITE-MAGNETITE ORES IN THE INSTANCE OF THE YELET'OZERO INTRUSION.
pp.61-74 Photocopy 20pp. $3.00, Order ref:SG60-3-5

Three complexes found in this succession 1) fine-grained gabbro, 2) coarse-grained gabbro, and 3) banded gabbro. 1 and 2 have disseminated titanomagnetite. In 3 have ilmenite and enrichment in apatite, pyrite, and amphiboles. Auther says is the result of increase in the volatile content in the magma during differentiation. Banded Ti ores are the result of crystallization of Ti-rich residual melt between layers of earlier isolated plagioclase crystals titano-magnetite in earlier differentiation products indicates higher temperature; ilmenite and magnetite in later ores indicates lower miscibility at lower temperature. A good paper describing cycles of differentiation and flow banding in steeply dipping rocks.

Obraztsova, Z.A., RELATIONSHIP BETWEEN THE TUNGSTEN AND POLYMETAL MINERALIZATIONS IN THE CENTRAL MINE (EAST TRANSBAIKAL REGION).
pp.75-88. Photocopy 17pp. $2.55 Order ref:SG60-3-6

A good report on mineralization of tungsten ores as related to somewhat younger Pb-Zn ores. Close association of ores with different types of dikes and also evidence for prolonged mineralization. Reminescent of the Front Range Mineral Belt in Colorado. Good paper but narrow in aspect.

Goretskiy, Yu. K. and Kalmykov, N.T., PROSPECTING FOR BAUXITES AND REFRACTORY ROCKS OF THE FLINT-CLAY TYPE IN PALEOZOIC COAL-BEARING DEPOSITS OF THE SIBERIAN PLATFORM.
pp.89-99. Photocopy 15pp. $2.25, Order ref:SG60-3-7

Article is of little general interest. Reports no bauxite or diaspore. Concerned mainly with flint clays in Carboniferous rocks. Of most interest are "weathering crusts" developed at important unconformity between Carboniferous and older, including lower Paleozoic, rocks.

Pavlov, B.S., EFFECT OF CRYOGENIC TEXTURES ON FROZEN FOUNDATIONS.
pp.100-105. Photocopy 9pp. $1.35, Order ref:SG60-3-8

This paper has considerable interest for the applied geologist but is so generalized that it probably is not worthy of republication.

Itenberg, S.S., APPLICATION OF GAMMA-RAY LOGGING DATA IN SOLVING SOME GEOLOGIC PROBLEMS.
pp.106-112. Photocopy 10pp. $1.50, Order ref:SG60-3-9

This paper appears to be of a general nature and would have limited appeal. Application is general and shows no new ideas that have not been published previously.

★Matveyev, P.S. and Nikiforov, A.V., THE EXTENT OF EXPLORATION OF A MINERAL DEPOSIT PREPARATORY TO ITS COMMERCIAL DEVELOPMENT.
pp.113-119. IGR, v.3, no.10 (this issue)

Short Notes

★Mal'kovskiy, F.S. THE EVOLUTION OF SALINE REGIMEN IN UPPER CARBONIFEROUS AND LOWER PERMIAN BASINS OF TATARIA AND ADJACENT REGIONS.
pp.120-121. IGR, v.3, no.10 (this issue)

Kirillov, A.S., BAUXITES ON THE WESTERN MARGIN OF THE SIBERIAN PLATFORM IN THE ANGARA REGION.
pp.121-123. Photocopy 4pp. $0.60, Order ref:SG60-3-10

Reports on discovery of bauxites in the Angara region of the Siberian platform in a non-karst environment, mainly alluvial remnants of disrupted bauxites. Author suggests probable lack of commercial deposits unless karst funnel relics can be found. Limited reader interest.

Blom, G.I., OLIGOCENE DEPOSITS IN THE VOLGA-VETLUGA WATERSHED.
pp.123-127 Photocopy 8pp. $1.20, Order ref:SG60-3-11

Good biostratigraphic summary on Oligocene deposits with emphasis on space-pollen analyses for correlation purposes. Limited reader interest.

Sinichka, A.M., DISTRIBUTION OF LOWER CRETACEOUS MOTLEY DEPOSITS IN THE DNEPR-DONETS TROUGH.
pp.127-130 Photocopy 6pp. $0.90, Order ref:SG60-3-12

Poorly written, incoherent report on some little known beds of little interest. The cause of the mottled character is never dealt with directly.

★Il'in, P.I., TYPES OF FOLDING OBSERVED IN COAL DEPOSITS OF THE SOUTHERN URALIAN BASIN.
pp.130-133 IGR, v.3, no.10 (this issue)

Khomizuri, P.I., REORGANIZATION OF SCIENTIC TERMINOLOGY.
pp.133-135 Photocopy 5 pp. $0.75, Order ref:SG60-3-13

The Russians let down their hair about their own domestic mess of geologic nomenclature. Not of international interest. Discloses vagaries of loose scientific writing in the Russian language.

Reviews and Discussions

★Teodorovich, G.I., REVIEW OF O.L. EYNOR'S BOOK "STUDY IN CARBONIFEROUS STRATIGRAPHY ON THE EAST MARGIN OF THE VOLGA-URAL OIL REGION".
pp.137-140 IGR, v.3, no.10 (this issue)

In the Ministry of Geology and Mineral Conservation of the U.S.S.R.

WORK SCHEDULE IN SCIENTIFIC RESEARCH INSTITUTES FOR 1960.
pp.141-142 Photocopy 4pp. $0.60, Order ref:SG60-3-14

Although this self evaluation and criticism may satisfy our curiosity, there is little or nothing of academic interest.

Scientific News

Gratsianova, O.P. and Fedynskiy, V.V., NEW GEOLOGIC RESULTS OF REGIONAL GEOPHYSICAL WORK.
pp.143-148. Photocopy 10 pp. $1.50, Order ref:SG60-3-15

Progress report of very general nature. Limited appeal.

Shavin, V.I., SOME PROBLEMS OF THE STUDY OF MESOZOIC DEPOSITS IN HUNGARY.
pp.148-150. Photocopy 5pp. $0.75, Order ref:SG60-3-16

This paper is of such a general nature that it offers nothing of interest to an international audience. It is not a first-class summary of an important conference of stratigraphy.

Tikhomirov, V.V. and Voskresenskaya, N.A., JOINT CONFERENCES OF EDITORIAL BOARDS FOR VOLUMES OF "THE STATUS OF GEOLOGICAL KNOWLEDGE OF THE U.S.S.R. (CAUCASUS AND SOUTHWEST EUROPEAN U.S.S.R.).
pp.150-151. Photocopy 3pp. $0.45, Order ref:SG60-3-17

Not of pertinent international interest.

THE STRUCTURE OF THE BASEMENT OF NORTHERN TURKMENIA AND KARAKALPAKIA ACCORDING TO THE RESULTS OF GEOPHYSICAL INVESTIGATIONS[1]

by

D.P. Kasatkin[2]

REVIEWER'S NOTE

Treats the Paleozoic basement structure and tectonics. Geologic conclusions of general interest and appeal, but geophysical part of interest to specialists only.

ABSTRACT

The results of using seismic prospecting aeromagnetic (ΔT) and gravimetric survey methods in studying the constitution of the folded foundation of North Turkmenia and Karakalpakia are given. According to the data of the Correlation Method of Refracted Waves the constitution of the foundation is characterized by a V refracted horizon coinciding with the top beds of the foundation. Magnetic research reveals the nature of constitution of the lower structural foundation stage. Gravimetric investigations show chiefly the composition and inner structure of the foundation, in many cases manifested also in the foundation surface structure. A division of geophysical fields into separate areas is made and the most probable version of the geological interpretation is given. A structural diagram of the surface and a tectonic map of the folded Paleozoic foundation are prepared. Both on the diagram and the map five structures of the first order of sublatitudinal strike are distinguished: the Buzachinsk — Zeravshan and Karakumy anticlinal zones; the Usturt-Kyzylkumy, Mangyshlak — Amu-Darya and South-Karakumy synclinal zones. Within the first order structures those of the second, third and fourth orders are isolated, showing both sublatitudinal and submeridional strikes.

The structural-tectonical pattern obtained predetermines the trend of prospecting exploration work for oil and gas. -- Auth. English summ.

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From 1952 to the beginning of 1958, extensive complex geophysical investigations were conducted in Northern Turkmenia and Karakalpakia by expeditions first of the Central, and then of the Western and Central Asiatic geophysical trusts. Aeromagnetic Surveys (ΔT), gravimetric surveys and regional seismic surveys (KMPV) were made throughout the entire area, and electrical surveys (VEZ) in individual parts of this area. The author of this article participated directly in these investigations as chief engineer of the expedition.

In addition to the materials resulting from the work described above, this article will also draw upon the data of gravimetric and seismic (KMPV) investigations made by the Central Asian Oil Geophysical Trust, gravimetric and aeromagnetic surveys made by Spetsneftegeofizika, VNIIGeofizika and the Kazakhstan Geophysical Bureau.

GENERAL AND METHODOLOGICAL DATA

The area covered by these investigations, 0.5 million km^2, embraces Northern Turkmenia and Karakalpakia, as well as the adjoining areas of Turkmenistan, Uzbekistan and Kazakhstan. A number of conclusions on the geologic structure of this region were drawn from geophysical and geological investigations made over a greater area (1.5 million km^2), extending to Mugodzhar and the Southeastern Transurals inclusive in the north, to the Caspian Sea in the west, to the Kopet-Dag and Paropamiz in the south and to Zeravshan, including the latter, in the east.

The basic technical data on the geophysical investigations carried out over this territory are given below.

1. Seismic prospecting was done by the refracted wave correlation method waves (KMPV) in the central part of the region, using a system of profiles 30 to 60 · 70 km, with somewhat more detailed study of individual areas (Nukus — Takhia-Tash, Dyuyeboyun, Koykyrlan, Karashor-Kaplankyr). The precision in the determination of the boundary velocities of the main refracting layers (II, III, IV and V) was from 3 to 5%, and the precision in the determination of the depths

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[1]Translated from Sovetskaya Geologiya, 1960, no. 1, p. 10-33.

[2]Glavgeologiya RSFSR.

for the V, IV and III layers was no less than 3 to 3.5%, for the II layer 5%, and for the I layer 15%.

2. The aeromagnetic survey (ΔT) was made on the scale of 1:200,000 and, in part (in small areas in the northern and western parts of the region under investigation), on the scale of 1:1,000,000. The aeromagnetic survey was accurate to ± 15 gammas.

3. The gravimetric survey throughout the greater part of the region was made by gravimeters, and data from general pendulum surveys were used only for the territory of the Zaunguz'ye. For the central parts of the region under investigation, along with maps of anomalies, maps of local gravitational anomalies were drawn (by using various methods of secondary vertical derivatives and averaging the fields by means of circumferential map squares), so as to determine the boundaries between the elements of gravitational fields of the first, second, third and sometimes fourth orders.

GEOLOGICAL DATA

According to the modern conceptions, which are based on papers by N.S. Shatskiy, A.L. Yanshin and D.A. Tugolesov [10, 11], the area of Northern Turkmenia, Karakalpakia and the adjacent region lies within the "Turan block of the Epipaleozoic platform, where the basement is compoased of pre-Paleozoic, Paleozoic and, in places, Triassic (including Rhaetian) deposits". The basement contains at least two stages. The lower stage is represented by a complex of rocks no younger than Middle Devonian, while the upper stage is composed of post-Middle Devonian rocks. The structures of the platform sedimentary mantle are inherited from the structures of the basements. The sedimentary mantle of the Turan block is also characterized by a two-stage structure: the lower stage is composed of Rhaetian-Liassic (and sometimes Lower Dogger) rocks, while the upper stage contains Dogger (and sometimes Upper Dogger) rocks.

Within this region the basement rocks are exposed in areas with the highest relief forms, with absolute elevations of + 400 m or more in the Sultan-Uizdag and Tuarkyr Hills, and has been revealed by drilling west and east of Nukus and in the Pitnyak area (Dyuyeboyun). In the immediately adjacent areas to the northwest, the basement rocks are exposed or have been revealed by drilling in the Mangyshlak, to the north in the Northern Ustyurt and the southern continuations of the Urals and the Mugodzhar (the Chushkakul' anticline and the Berchogur syncline), to the east in the Northern Kyzylkumy, and to the southwest in the Greater Balkhan and the Krasnovodsk Peninsula.

According to geologic observations and drilling data, the thickness of the deposits forming the Mesozoic and Cenozoic platform sedimentary mantle over the territory under investigation varies from zero in the areas where the basement is exposed to 2,000 m in the territory of Pitnyak (Dyuyeboyun), and is inferred to be considerably more than 2000 m within the Sarykamysh delta of the Amu-Dar'ya river. Within this region there are two zones of uplift: the Priamudar'ya (the Sultan-Uizdag, Pitnyak uplifts and others) in the northeastern and the Tuarkyr zone (the Tuarkyr and Karashor uplifts) in the southwestern part. The structures in these zones have different trends: subequatorial and submeridional in the first, and north-northwest in the second. Between the Priamudar'ya and the Tuarkyr zones, drilling operations have established still one more uplift — the Sernozavodsk uplift. North of the latter, the Akhchakinsk uplift is tentatively located. The uplifts are separated by the depressions of the Sarykamysh delta of the Amu-Dar'ya River, the Verkhne-Uzboysk basin and the Uchtagan basin (between the Karashor and Tuarkyr).

PHYSICAL PROPERTIES OF THE ROCKS

Table 1 generalizes all the data on the physical properties of the various rock complexes developed in the region under consideration; these data are derived from laboratory identifications of rock specimens and from field investigations [7, 8], and also taken from the literature sources [2, 3, 5, 9] on the adjacent regions.

As mentioned earlier, according to the seismic data there are five refractive strata which are almost universally distributed throughout the region studied, and which are readily recognized and correlated. On the basis of KMPV observations in areas characterized by natural rock outcrops and deep drill holes, the following stratification of the refracting strata has been determined: stratum V — top of the folded Paleozoic basement, IV — top of the lower structural stage of the platform mantle, III — top of the Lower Cretaceous and Upper Jurassic carbonate deposits, II — top of the Lower Eocene-Upper Cretaceous carbonate deposits or top of the Upper Cretaceous, I — top of the Miocene carbonate deposits.

The boundary velocities of stratum V vary within wide limits, from 3.4 to 7 km/sec, while V_b has large average values of 5.5 to 6 km/sec for the lower structural stage of the basement and from less than 5.5 to 5 km/sec for the upper structural stage. The boundary velocities of stratum IV change (smoothly) from 3.9 to 5.5 km/sec, those of stratum III from 3 to 4.8 km/sec, and those of II from 2.8 to 3.6 km/sec.

The rocks composing the platform mantle

and upper stage of the basement within the territory under consideration and its adjoining ageas are almost non-magnetic. The rocks of the lower structural stage of the basement are characterized by a broad differentiation in magnetic properties, so that it can be assumed that all the souces of the magnetic anomalies are included in this stage alone. The distinct active gravitational boundaries are those along the tops of the lower and upper stages of the basement, the top of the lower stage of the mantle, and the top of the Cretaceous in the Kopet-Dag geosyncline. To the first approximation, at least for the greater, or central, part of the region, it may be assumed that there is only one active boundary, which coincides with the top of the basement. In this case the density of the Mesozoic-Cenozoic layer is approximately 2.25, and the average density of the basement rocks is 2.6 where there is a two-stage structure (usually in the zones os subsidence of the lower stage), and 2.75 where the basement is represented by only the lower stage (usually in the zones of uplift of the lower stage).

GENERAL FEATURES OF THE STRUCTURE OF THE BASEMENT ACCORDING TO THE DATA OF VARIOUS GEOPHYSICAL METHODS

The structure of the basement, according to the results of seismic surveys (KMPV), is characterized by five refracting layers which differ in a number of features from the overlying strata of the sedimentary mantle. From the V refracting layer arises a single, low-intensity but stable wave which dies out extremely slowly with distance. This wave as a rule has greater velocity than the wave refracted from the overlying strata. The velocity of this wave frequently changes discontinuously along the profile. Moreover according to the data from medium-frequency seismic surveying, the V refracting stratum is the last seismic layer in the section. The refractions (and reflections) below the V layer — that is, below the top of the Paleozoic basement — may possibly be observed in areas where the Paleozoic basement has a two-stage structure and the rocks of the upper stage are relatively slightly dislocated, occurring in facies of intermediate nature between geosynclinal and platform (Central Ustyurt, Berchogur). From the V layer, where it occurs at depths of no more than 1,000 m, in addition to the refracted waves, there are also other types of "basement" waves — diffracted, with high velocity, and reflected.

In contrast to those of the V stratum, the waves that arise from the layers (IV - I) of the sedimentary mantle are usually characterized by greater intensity, more rapid extinction, and smooth changing of the boundary velocities. The structure contour map drawn from the data of the V layer and the seismic sections provides the first evidence for judging the depth at which the surface of the basement occurs and its structure within the region under consideration. The contours of the Priamudar'ya and the Tuarkyr-Karashor zone of uplifts trending northwest have been clearly drawn, and the Sarykamysh-Sernozavodsk zone of uplifts has also been found and contoured. The southeastern part of the latter, which has the form of an arch, may be called the Zaunguz or Central Karakumy arch. The structural map of the basement surface — the structure contour map of the V refracting layer — clearly shows the outlines and structure contours of the Dar'yalyk'-Amu-Dar'ya zone of depressions in the basement, which separate the Priamudar'ya and the Sarykamysh-Sernozavodsk zones of uplift, as well as the structure contours of the Verkhne-Uzboy basin separating the Sarykamysh-Sernozavodsk zone from the Karashor spur of the Tuarkyr zone of uplifts. Individual seismic profiles have established the Tuarkyr uplift of the basement and the Uchtagan depression, which separates this uplift from the Karashor uplift, as well as the Aybugir uplift, which coincides with a corresponding uplift in the Cretaceous deposits.

The boundary velocities are observed to increase regularly in the zones of uplift and decrease in the zones of depressions. This, in the present writer's opinion, is explained by the fact that the uplift zones contain ancient rocks, which are more metamorphosed and therefore characterized by higher boundary velocities; in the zones of depression, on the other hand, the basement is represented by younger, and consequently less metamorphosed rocks, which thus possess lower boundary velocities.

From the data of the magnetic survey, using the tangent method for clearly double-measured positive (relatively high) anomalies, calculations were made of the depths down to the top of the magnetically active rocks. A comparison of the structure contour map of the V layer with the structure contours of the top of the magnetically active rocks indicates that they are quite similar, except for the area of the Mangyshlak anticlinorium.[3] Thus the magnetic depths are usually proportional to the depths down to the V refracting stratum. These magnetic depths, however, in the majority of cases are exaggerated in comparison to the depths down to the V layer; equal depths occur rarely and lower values of the former as compared to the latter occur still more rarely. The smallest discrepancies between these depths have been observed in the zones and areas of uplift, and the

[3] The accurate determinations of the depth of the top of the magnetic rocks (10 to 20%) and the magnitudes of the absolute level of the topographic surface (on the average to about 0.1 km) make it possible to calculate the lines of equal depth (using absolute values) from the structure contours.

Table 1

Age of rock complex	Composition	Structural stage	Velocity, km/sec: in layer	Velocity, km/sec: at border between layers	Density g/cm^3	Magnetic properties	Location
Upper Neocomian-Quaternary	Sandy-clay rocks, with smaller amounts of carbonate	Upper sedimentary mantle of platform	Upper layer, 1.3 to 1.8 Lower layer, 2.0 to 3.0	0.3 to 3.6 (individual layers) 2.8 to 3.6 (II boundary layer)	1.78 to 2.16	Non-magnetic	Northeastern Turkmenia, Karakalpakia, Dyuyeboyun
Tertiary	Same	Same	—	—	1.96 to 2.46	Same	Western Kopet-Dag, Lesser and Greater Balkhan
Middle Jurassic-Lower Neocomian	Sandstones, clays	Same	3.1 to 3.3	3.0 to 4.6 (III boundary layer)	2.27	Same	Northeastern Turkmenia, Karakalpakia
Middle Jurassic-Neocomian	Same	Same	—	III boundary layer 4.8 (III boundary layer)	2.2	Same	Chuchkakul' anticline, Northeastern Ustyurt
Rhaetic-Liassic	Clays, sandstones	Lower sedimentary mantle of platform	4.4 to 4.5	3.9 to 4.8 (IV boundary layer)	—	Same	Northeastern Turkmenia, Karakalpakia
Same	Same	Same	—	5.2 to 5.5 (IV boundary layer)	2.42	Same	Dyuyeboyun, Tuarkyr
Same	Argillites	Same	—	—	2.4 to 2.5	Same	Chushkakul' anticline, Northeastern Ustyurt
Jurassic-Cretaceous	—	Top layer of basement?	—	—	2.4 to 2.64	Same	Western Kopet-Dag, Lesser and Greater Balkhan
Mesozoic-Cenozoic	Primarily sandy-clayey rocks	Sedimentary mantle of platform	—	—	2.25	Non-magnetic	Central part of the area
Permian-Triassic	Molasse deposits	Top layer of basement	—	4.6 to 5.2 (V boundary layer)	2.6	Same	Mangyshlak
Same	Same	Same	—	4.9 to 5.3 (V boundary layer)	—	Same	Sarykamysh delta

Upper Paleozoic	Granites	Same	—	4.5 (V boundary layer)	2.57	Same	Dzhimurtau, Sultan-Uizdag
Upper Devonian-Upper Carboniferous	Terrigenous sequences, carbonate rocks	Same	—	3.4 to 4.6 (V boundary layer) 4.7 to 6.0 (V boundary layer)	2.6	Same	Berchogur syncline
Upper Devonian-Carboniferous	Sedimentary rocks	Same	—	—	—	Same	Northwestern Kyzylkumy
Gotlandian (Upper Silurian) - Middle Devonian	Sedimentary and igneous rocks	Lower layer Basement	—	4.5 to 6.0 (V boundary layer)	2.75	Wide differentiation	Berchogur syncline
Gotlandian-Middle Devonian	Metamorphic and volcanic rocks	Same	—	5.2 to 5.6 (V boundary layer)	2.7	Non-magnetic or weakly magnetic	Sultan-Uizdag
Gotlandian (Upper Silurian)	Limestones altered to marble	Same	—	4.6 to 5.0 (V boundary layer)	2.62	Non-magnetic	Same
Lower Paleozoic	Amphibolites	—	—	5.8 to 6.2 (V boundary layer)	3.05	Strongly magnetic	Same
Lower Paleozoic, Gotlandian, Middle Devonian	Sedimentary and igneous rocks	Same	—	5.5 (entire sequence)	2.75 (entire sequence)	Wide differentiation	Same
Same	Same	Same	—	6.0 (V boundary layer)	2.75	Wide differentiation	Tuarkyr, Krasnovodsk peninsula

greatest in those of depressions. In addition, special cases occur: anomalously high values of the magnetic depths in five local areas of the region under consideration (the depths have been decreased in such areas in constructing the structure contour maps) and within the Mangyshlak anticlinorium.

The relationships between the depths, as well as the physical properties of the rocks, indicate that in the zones of uplift of the basement the magnetic and seismic data are indicating the same boundary — the top of the lower structural stage; in the zones of depression the magnetic data are also describing the top of the lower structural stage, whereas the seismic data (depths down to the V layer) refer to the top of the upper structural stage of the basement. The anomalously high values of the magnetic depths within the Mangyshlak anticlinorium, as concluded from a combination of the magnetic and seismic data, are explained by the fact that here the magnetic rocks of the lower structural stage contain a deep depression filled with the non-magnetic rocks (Permian-Triassic) of the upper structural stage; these occur in the form of an inverted anticlinorium (in the terminology of V. V. Belousov, [1]). The anomalously high magnetic depths noted in the above-mentioned five local areas probably mark the occurrence of deep faults in the basement which contain magnetically active masses occurring far below the top of the lower structural stage of the basement.

There is a close interrelationship between the structure contour map of the top of the magnetic rocks and the map of the lines of equal magnetic intensity (ΔT_a). As a rule (at least for all the structures of the first and second orders) the uplifts of the top of the magnetic rock layer are controlled by negative (lower) magnetic fields, and the depressions by positive (higher) magnetic fields.

According to the structure contour map of the top of the magnetic rocks, the basement contains several regional zones (first-order structures). In the northeastern part of the area investigated, there is a zone of subsidence where the top of the magnetic rocks descends by a depth of 4 to 7 km, associated with the northern part of the Sarykamysk delta of the Amu-Dar'ya River, and extending thence eastward, first in a subequatorial and then (from the Sernozavodsk profile) submeridional direction, mainly along the left bank of the Amu-Dar'ya River. This zone corresponds to the Dar'yalyk-Amu-Dar'ya depression in the V horizon — the top of the basement — but occupies a greater area. The zone of depression throughout its extent is controlled by a clearly marked zone of maximum (positive) magnetic field, whose intensity is 100 to 300 gammas or more. West of the Sarykamysh Delta, this zone of depressions and the intensive positive magnetic field that controls it project in a subequatorial direction as far as the western end of the Mangyshlak Peninsula; the Mangyshlak dislocational and orographic system and its eastern continuation (according to our data, the Karabaur swell and the Aybugir uplift) follow the axial part of the zone. The zone as a whole is called the Mangyshlak-Amu-Dar'ya synclinal zone.

To the north of the Mangyshlak-Amu-Dar'ya synclinal zone extends the Buzacha-Zeravshan anticlinal zone, and to the south the Karakumy anticlinal zone. The first is bounded on the west and south by structure contours on the 3-km level, which coincide almost exactly with the structure contours of the 2-km V layer. The second is bounded by a 5-km structure contour and includes three more local zones of uplift (of the second order) of the V layer — the Sarykamysk-Sernozavodsk, the Karashor and the Tuarkyr zones. These zones (or their individual elements) are bounded by 3-km structure contours, coinciding approximately with the 2.5-km structure contours on the structural map of the V layer. Both anticlinal zones are controlled mainly by a lower — negative — magnetic field, and as a result (as well as from the seismic data) may be traced clearly: the northern zone from the Priamudar'ya uplifts to the Northern Buzacha uplift in the west and to the Zeravshan anticlinal zone in the east; the southern zone extends westward as far as the Kara-Bogaz-Gol.

In the southern part of the region under consideration one may distinguish the Southern Karakumy zone of depressions, and in the northern part of the Ustyurt-Kyzylkumy synclinal zone. The first-order zones have a subequatorial trend, whereas the zones of the second and lessor orders have subequatorial and submeridional trends.

In the Karakumy zone and in the Priamudar'ya areas of the Mangyshlak-Amu-Dar'ya zone, the second-order and lessor structural elements have submeridional trends; subequatorial trends are to be found in the majority of structures in the Mangyshlak part of the Mangyshlak-Amu-Dar'ya zone and in the southern part of the Nukus Sultan-Uizdag zone of uplifts. If one compares the magnetic (structure contours, isodynes) with the seismic (structure contours and boundary velocities of the V layer) maps, one may conclude that these systems of predominant trends are not related to each other.

The field of gravitational anomalies contains four regional zones of gravitational maxima (the Priamudar'ya, the Sarykamysh-Sernozavodsk the Karashor-Tuarkyr and the Mangyshlak) and four zones of minima (the Dar'yalyk-Amu-Dar'ya, the Verkhne-Uzboy, the Southern Karakumy and the Northern Ustyurt-Aral). According to the seismic and magnetic survey data, all these regional zones, except for the Mangyshlak zone of maxima, correspond approximately to

the same respective structural zones of the basement. The Mangyshlak zone, according to the magnetic survey data, corresponds to the most downwarped axial part of the basin in the lower structural stage of the basement of the Mangyshlak-Amu-Dar'ya zone in the area from Aybugir to Mangyshlak and, according to the seismic data, to an uplift in the same area in the upper structural stage of the basement. Thus the Mangyshlak zone of greatest magnetic intensity must be due chiefly to the uplift in the upper structural stage of the basement.

The regional zones of gravitational anomalies contain anomalies of secondary + lesser orders. In some cases these show a reverse relationship, and in others there is no relationship at all between the Δg field and the structures of the basement.

Analysis of the field of gravitational anomalies and its transformations — that is, of the fields of local anomalies — as well as of the seismic and magnetic survey data, has suggested a number of conclusions regarding the structure and rocks of the basement in many parts of the region under consideration.

GEOPHYSICAL REGIONALIZATION AND ITS POSSIBLE GEOLOGIC INTERPRETATION

The geologic interpretation of the regionalization of geophysical fields is based on four factors: 1) the relationship at depth between the seismic and magnetic survey observations, 2) the magnitudes of the boundary velocities of the V layer and the nature of the field of gravitational anomalies, 3) the nature of the ΔT_α field and 4) the geologic data (outcrops and drill holes).

The diagram in Figure 1 shows the H and B zones. According to the seismic and magnetic data, the H zones are clear zones of uplift of the Paleozoic basement characterized by the smallest discrepancies between the seismic and magnetic depths of the basement ($H_M/H_S \approx 1$), as well as zones of higher boundary velocities in the V layer, where V_b = 5.5 to 6 km/sec, and also zones of predominant maxima of Δg and of decreased (negative) ΔT_α fields; within the H zones, as a rule, the rocks of the lower structural stage of the basement are exposed in outcrops or revealed by drilling.

The first and fourth factors quite clearly indicate that the basement within the H zones is composed of rocks of the lower structural stage. This is apparently also indicated by the second and third factors (V_b, Δg, ΔT_α). The generally low ΔT_α field in the H zones indicates that here the magnetic formations, which are usually complexes of basic and ultrabasic rocks, are not widespread, and that non-magnetic rocks — sedimentary deposits, volcanogenic metamorphic formations and granitoids — are predominant. The higher values of V_b and Δg characteristic of these formations are explained by their intensive metamorphism. The latter is true only of the ancient rocks of the lower structural stage, or else of the younger rocks of the upper stage that were formed under conditions of particularly great geotectonic stress.

Within the region under investigation there are two large zones with characteristic indications of the H zones — the Buzacha-Zeravshan and the Karakumy anticlinal zone. The basement of the first is exposed in the Sultan-Uizdag mountains and has been revealed by drilling in the Nukus-Khodzheyla and Pitnyak (Dyuyeboyun) areas, while the second has been revealed in the Tuarkyr. Rocks no younger than Middle Devonian (primarily S_2 - D_2) have been revealed in these areas. The only exceptions are the small, presumably Upper Devonian, granite intrusions of the Sultan-Uizdag and the deposits of Permian age (the Amanbulak suite) of the Tuarkyr. The former, because of their limited distribution, are not important. The second apparently form part of the composition of the lower structural stage of the platform mantle, inasmuch as in the Tuarkyr there is a clear correspondence between the seismic (V layer) and magnetic (top of the magnetically active rocks) depths.

The H8, H7, H6 and H5? zones have been distinguished from the relationships between the observed magnitudes of V_b, Δg and ΔT_α. The H8 zones are very clearly marked in the areas characterized by the highest seismic and magnetic boundaries, values of V_b = 6 km/sec, maxima of Δg and the lowest ΔT_α fields, on the order of - 100 gammas or less. Such areas, as shown in Figure 1, exist in the eastern part of the region under consideration (the Sultan-Uizdag and south of Pitnyak); in the central parts (the Sarykamysh-Sernozavodsk zone of uplifts), in the Shakhsenema-Adzhikuyu, the eastern part of the Sarykamysh basin and the central part of the Unguz; and in the western parts of the region, in the Tuarkyr area.

The H8 zones are characterized by features typical of a number of areas in the Voronezh crystalline shield, where the basement is represented by highly metamorphosed Precambrian sedimentary rocks and igneous formations of the gneiss and migmatite type. In the Sultan-Uizdag the H8 zones contain serpentinized rocks of Early Paleozoic age; the Shakhsenem-Adzhikuyu area is ringed by magnetic anomalies in a manner typical of the areas of the ancient consolidated basement of the Russian platform. Thus the basement of the H8 zones in the Sultan-Uizdag and in the Sarykamysh-Sernozavodsk zone of uplifts seems to be composed chiefly of metamorphosed Early Paleozoic (or even Precambrian) sedimentary formations. A basement of this age and composition has also been suggested for the

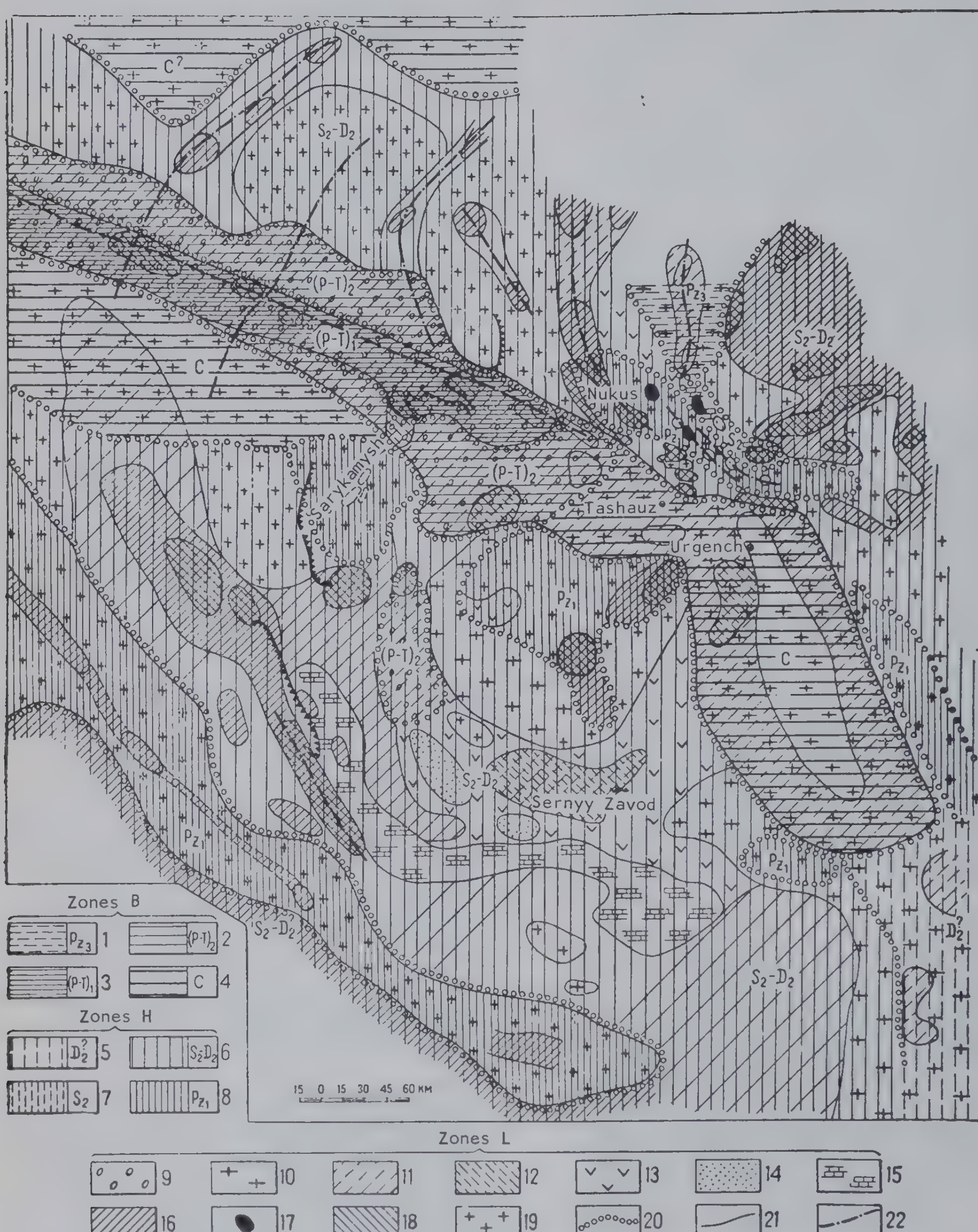

FIGURE 1. Diagrammatic regionalization by geophysical zones (H_m/H_c, V_b, Δg, ΔT_α) of the area of Northern Turkmenia and Karakalpakia. The B and H zones, in which the structural and physical elements have been studied, tentatively characterize the stratigraphy, and the L zones, in which the physical elements have been studied, the lithology of the Paleozoic basement. Zones: 1 - B1; 2 - B2; 3 - B3; 4 - B4; 5 - H5?; 6 - H6?; 7 - H7; 8 - H8; 9 - L9; 10 - L10; 11 - L11; 12 - L12: 13 - L13; 14 - L14; 15 - L15; 16 - L16; 17 - L17; 18 - L18; 19 - L19; 20 - inferred stratigraphic boundaries; 21 - inferred lithologic (and physical) boundaries; 22 - axes of zones of inferred tectonic dislocations.

areas of Pitnyak and the Tuarkyr. Here, however, another geologic interpretation of the H8 zones is possible — that they represent highly metamorphosed pre-Upper Devonian rocks of the basement formed under a regime of high tectonic stress. This interpretation is also in some measure supported by the anomalously high values of V_b in the lower layers of the platform mantle, and by the linear nature of the magnetic and gravitational anomalies of Pitnyak and the Tuarkyr.

The H7 zone in the Sultan-Uizdag occupies a small area and is characterized by the following magnitudes: $V_b \approx 5$ km/sec, $\Delta T_\alpha < 0$, and a minimum Δg. Within this zone are exposed mainly marble limestones of the S_2 age.

The H6 zones are characterized by the above-mentioned average values of the H zones, suggesting that the extensive areas of these zones contain primarily metamorphosed sedimentary and granitoid formations.

In the B zones one observes the greatest discrepancies in the depths down to the V layer, which has a synclinal and partly anticlinal occurrence, and down to the top of the magnetically active rocks, which form a syncline; the lower values of the boundary velocity of the V layer ($\nless$ 5 to 5.5 km/sec) and a field of intensive gravitational anomalies, with several individual maxima; and for the most part a positive ΔT_α field (100 to 300 gammas or more). The V zone marks the Mangyshlak-Amu-Dar'ya synclinal zone which separates the Buzacha-Zeravshan from the Karakumy anticlinal zones. In the Mangyshlak B zones there are exposures of Permian-Triassic folded molasse complexes, and in the east, in the Aybugir area, similar rocks have been encountered by boreholes recently drilled by the SGPK. According to the complex of values in the B zones, which control the Mangyshlak-Amu-Dar'ya structural zones, the basement is composed of sedimentary rocks of the upper structural stage, overlying highly magnetic rocks — basic and ultrabasic — of the lower structural stage. Areas with similar characteristics have been discovered by geophysical methods in the Chimbay region and west of Akhchakay; the geologic structure of these areas may be considered to be similar to that of the Mangyshlak-Amu-Dar'ya zone.

According to the relationships between V_b, Δg and ΔT_α, as shown in Figure 1, the zones B4, B3, B2 and B1 have been distinguished. In the B4 zone the value of V_b of the V layer is approximately 5.5 km/sec, whereas in the remaining zones it is on the order of 5 km/sec or less. Another basic difference between the B4 zones and the remaining ones is that the latter in individual areas contain nagative magnetic fields. These data indicate a high degree of metamorphism of the sedimentary complex of the upper stage of the basement in the B4 as compared to the B3, B2 and B1 zones. Since the age of the basement rocks in the latter zones is chiefly Permian-Triassic, it may be concluded that the upper stage of the basement is divided into two substages: an upper substage of Permian-Triassic rocks and a lower substage represented by more metamorphosed (and older) Carboniferous and Upper Devonian formations. The extensive Assakeaudan area of the B4 zones corresponds, according to the data resulting from a combination of methods, to the area of the Southern Mangyshlak depression in the basement. For this reason the latter may here be assigned to the lower (Carboniferous — Upper Devonian) substage on the basis of structural considerations as well.

According to a number of indications, geologic data and data on the physical properties of the rocks, the basement of the B3 and B2 zones consists of low-velocity molasse deposits of Permian-Triassic age. The B3 zones differ from the B2 zones in that the former show linear Mangyshlak-type Δg maxima and an uplift in the V refracting layer, associated, as mentioned above, with the axial part of the basin in the lower structural stage of the basement and with a corresponding inverted anticlinal uplift composed of the Permian-Triassic rocks of the upper structural stage of the basement. From these structural circumstances it will be concluded that the basement rocks are older in the core of the inverted uplift (the B3 zone) and younger in its flanks (the B2 zones). It may be supposed that the B3 zones contain rocks of the lower part of the Permian-Triassic (PT_1), and that the B2 zones contain rocks of the upper part of the stratigraphic interval (PT_2).

In their structural and physical characteristics, the B1 zones are very similar to the B2 zones, except for the depths of their occurrence (1.5 and 3 km respectively). Thus the basement rocks of the B1 zones may be considered as Upper Paleozoic (Pz_3) — that is, it may be supposed that the basement here contains both Permian-Triassic rocks and low-velocity, probably terrigenous, rocks of the Carboniferous.

The characteristic values for the H6? zone, located in the southern and southwestern parts of the region under investigation, differ from the average values of the B zones in that within the former, the depths to the V layer and to the top of the magnetically active rocks are approximately equal, and V_b is more than 6 km/sec. This is the basis for concluding that within the H6? zone, in spite of the regional depression of the basement, it contains no rocks of the upper structural stage; the basement here, as in the zones of regional uplift, is represented by the lower structural stage, whose upper part is composed of Middle Paleozoic magnetic, predominantly basic rocks of S_2 - D_2 age. The H5? zone is located in the southeastern part of the region, within the area south of the Western

Table 2

No.	Zone	V_b (km/sec)	Nature of the Δg field	Nature of the ΔT_α gamma field	Stratigraphy or lithology of basement: according to geologic data	Stratigraphy or lithology of basement: inferred	Notes
				$\frac{H_m}{H_s} > 1.5$ to 2			H_m - depth to basement according to magnetic data H_s - depth to basement according to seismic data
1	B1	$\leqslant 5$	Minimum	< 0	—	P_{z3}	
2	B2	$\leqslant 5$	Minimum	> 100	P-T at Mangyshlak	$(P\text{-}T)_2$	
3	B3	$\leqslant 5$	Maximum	> 200	Aybugir	$(P\text{-}T)_1$	
4	B4	≈ 5.5	Minimum	< 0 (in parts)	—	C	
	B4 ?		Minimum	< 0	Northern flank of the Mangyshlak zone	C ?	
				$\frac{H_m}{H_s} - 1$			
5	H5 ?	—	Maximum	< 0	—	D_2	
	H6 ?	≈ 6	Minimum	> 100	—	S_2 - D_2	$\frac{H_m}{H_s} \approx 1$
6	H6	≈ 5.5	Maximum	< 0	S_2 - D_2 Sultan-Uizdag, Tuarkyr		
7	H7	≈ 5	Minimum	< 0	S_2 Sultan-Uizdag	S_2	
8	H8	≈ 6	Maximum	< -100	Pz Sultan-Uizdag (in local areas)	Pz_1	
L zones within B zones							
9	L9	≈ 5	Varied	Varied	P-T Molasse, Mangyshlak and Aybugir	Same	
L zones within B and H zones							
10	L10	≈ 5.5	Minimum	Varied		Sedimentary rocks	

11	L11	$\leqslant$5 to 5.5	Minimum rarely maximum	>0-100		Basic rocks, unexposed or cropping out in the top of the lower stage of the basement	
12	L12	≈5 to 5.5	Maximum	>100-200		Ultrabasic rocks, unexposed or cropping out in the top of the lower stage of the basement	
L zones within H zones							
13	L13	≈5	Minimum	0-100	Volcanogenic rocks S_2 - D_2, Sultan-Uizdag	Same	H6 zone
14	L14	≈5	Very small minimum	<0	—	Halogenic or granitoid rocks	H6 zone
15	L15	≈5	Minimum	<0	Limestones altered to marble S_2, Sultan-Uizdag	Same	H7 zone
16	L16	$\leqslant$6	Maximum	>0-100	Basic effusives (Sultan-Uizdag, Tuarkyr, Krasnovodsk peninsula)	Basic rock	H8, K6 zone
17	L17	>6	Very large maximum	<0	—	Accumulations of non-magnetic ores	H8 zone, Δg maximum not associated with uplift of the basement
18	L18	>6		>200-300	Amphibolites, Sultan-Uizdag	Same	In H8, H7, H6 zones
19	L19	5.7 to 6	Maximum	<0-100	Metamorphic formations, Sultan-Uizdag	Same	In H8 and H6 zones

Amu-Dar'ya part of the regional Mangyshlak-Amu-Dar'ya depression. Here one observes an elevation of the top of the magnetically active rocks, a local rise in the gravitational anomalies, and a negative ΔT_α field. These data indicate a positive undulation, or projection, of the basement composed of a complex of non-magnetic rocks (primarily sedimentary or granitoid). Since northward of this area, where the basin is considerably lower (the meridional V4 zone), its age has been determined as Carboniferous, this projection may be composed of older series, tentatively of rocks of the upper part of the lower structural stage (D_2?). The B4? zone is located in the extreme northern part of the region and is characterized by a depression of the top of the magnetically active rocks, a Δg minimum and a negative ΔT_α field. These indications together suggest that the basement is here probably composed of the lower rock complex of the upper structural stage, represented by non-magnetic, sedimentary formations of the Carboniferous (C?).

The identification and subsequent interpretation of the L zones (see Figure 1) is based on the same four factors that were mentioned above. Whereas the first and fourth factors, however, are the most important in the case of the H and B zones, in the L zones the chief factors are the second, third and fourth.

On the basis of the relationship between the fields (V_b, V layer, Δ_g, ΔT_α), we have distinguished eleven zones. These zones characterize the composition and lithology of the basement. The properties of the L zones, as well as those of the H and B zones, are shown in Table 2.

Among the zones of tectonic dislocation of the basement, as shown in the attached illustration (see Figure 1), two systems have been noted: one with a submeridional or northeastward trend and the other with a subequatorial (Mangyshlak-Eastern Sultan-Uizdag) trend. The first system is characteristic of the northern part of the region under consideration. It is represented by narrow zones of dislocation that intersect the subequatorial Buzacha-Zeravshan and the Mangyshlak structural zones. These tectonic zones have been identified as belts of intensive positive magnetic anomalies, whose sources occur as a rule beneath the top of the V layer. They are apparently areas of ultrabasic rocks that fill the deep faults in the basement and thus have only limited contacts with the top of the basement.

The second system of tectonic zones, which is primarily subequatorial, has the same trend as the structural elements. The zone of intensive positive magnetic anomalies associated with the axial parts of the Mangyshlak depression is apparently such a tectonic zone.

These tectonic zones may also possibly be contact zones, in which the normal stratigraphic succession of the rocks is disrupted.

THE STRUCTURE AND TECTONICS OF THE PALEOZOIC BASEMENT

On the basis of the maps and diagrams drawn from the results of our investigations of this region, by the three geophysical methods described above, as well as the regionalization by geophysical fields and its geologic interpretation (see Figure 1), we have made a structural-tectonic regionalization of the basement of the territory under consideration. To avoid overcrowding the map, the structures of the surface (Figure 2) and the tectonic map of the Paleozoic basement (Figure 3) are presented separately.

Our diagram of the structure of the basement surface has been constructed from the structure contour map of the V layer, from interpolations and extrapolations of the data on this map into areas where seismic studies were not made, from the structure contour map of the top of the magnetic rocks, and from maps of the Δg and, in part, the ΔT_α anomalies. For purposes of topographic orientation, the diagram shows structures of the first, second and sometimes third orders. The tectonic map (see Figure 3) shows the boundaries between the structures of the first, second, third and higher orders, as well as certain zones of tectonic dislocations.

To depict structures of the third and higher orders, notations from the various geophysical methods and from the geologic data were combined on the large-scale maps. In the central part of the area under investigation, where seismic surveys were made, the local structures (third-order and others), were with rare exceptions distinguished according to the criteria of all three methods that were suggestive of structures of this type. In the case of positive structures, such criteria were: 1) the reflection of the structures in the behavior of the V layer (the structural plan and curvatures in the profile) and in the layers of the platform mantle (IV, III, II layers); 2) reflections of the structures in the behavior of the top of the magnetic rocks; 3) maximum values of Δg and extreme (for the most part minimum) values of ΔT_α. In this process, of course, the geologic data, especially the results of drilling, were also taken into account.

The local structures outside the central part of the region — that is, in areas where seismic work was not done — were distinguished on the basis of the appropriate (for the type of structure) favorable indications from magnetic and gravimetric surveys. For positive structures such criteria included the following: uplifts of the top surface of the magnetic rocks, maximum values of Δg and extreme (chiefly minimum)

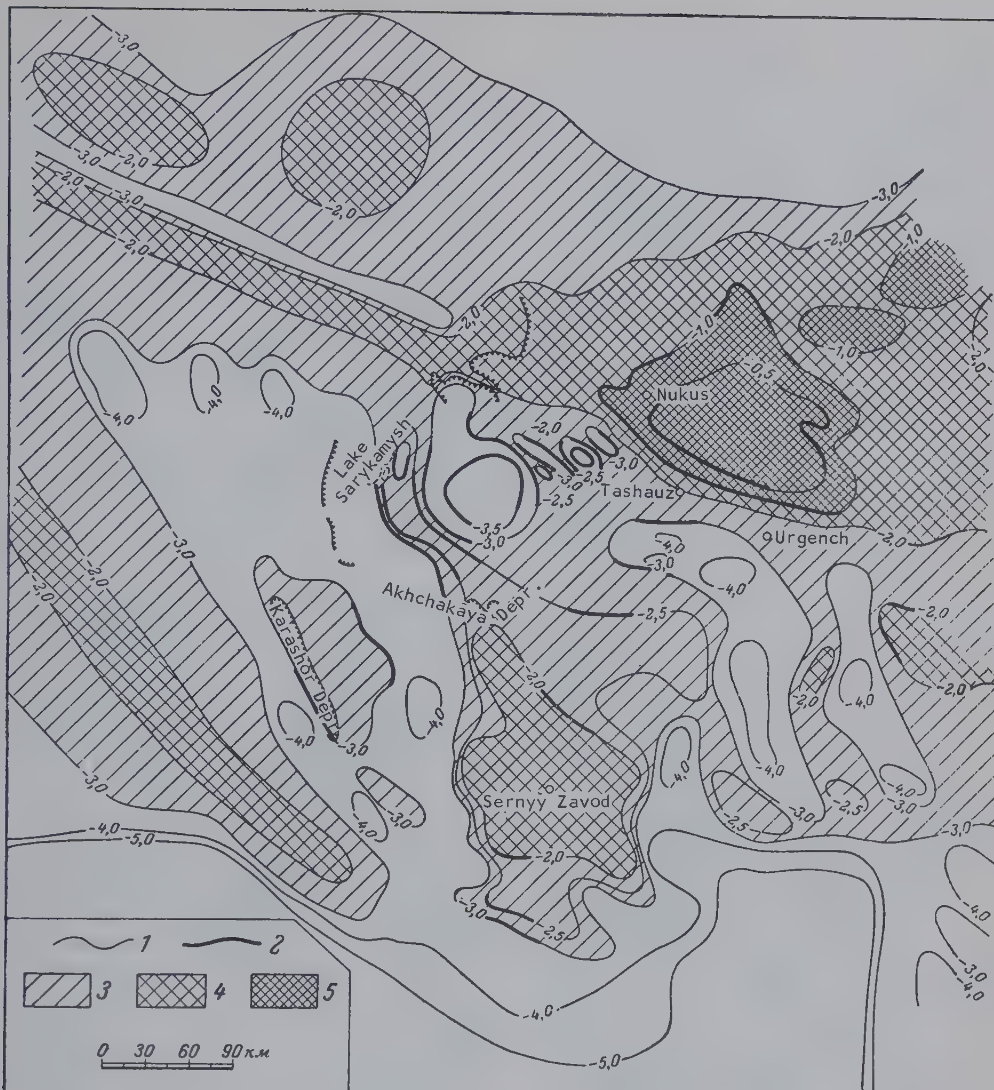

FIGURE 2. Diagram of the structures on the surface of the Paleozoic basement in the area of Northern Turkmenia and Karakalpakia and adjacent regions: 1 - structure contours on the surface of the Paleozoic basement and their depths in km; 2 - same, according to seismic survey data. Depth zones: 3 > - 3 km, 4 > - 2 km, 5 > - 1 km.

values of ΔT_{α}. Only a few local structures of the Mangyshlak meganticlinorium (positive) and the western part of the Mangyshlak folded zone (negative) were distinguished on the basis of gravimetric surveys alone, and within the Buzacha-Zeravshan zone on the basis of magnetic surveys alone (the Northern Barsakel'mess anticlinal structure and others). It is interesting to note that a number of maximum values of Δg were associated not with local uplifts, but with depressions in the top of the basement (the Uchtagan depression and other areas). The smallest of the reliably established (confirmed by seismic prospecting) positive structures of the third and higher orders were 2 · 6 km, and the largest (the Eastern Sarykamysh structure) was 20 · 90 km. The amplitudes of these structures varied within wide limits from 200 to 1600 meters, and in some cases were less than 200 meters — that is, they were smaller than the margin of error in determining the depth of the V refracting layer.

In making our structural-tectonic regionalization we used the terminology that is usually applied to folded regions. This was done because the structure of the basement was described as if the platform mantle had been

FIGURE 3. Tectonic map of the Paleozoic basement of the area of Northern Turkmenia and Karakalpakia

1 - boundaries between anticlinal and synclinal zones; 2 - boundaries between anticlinoria and synclinoria or depressions; 3 - anticlines, uplifts; 4 - synclines, basins; 5 - axes and boundaries of zones of tectonic dislocation; 6 - stratigraphic boundaries; 7 - positive structures, confirmed; 8 - the same, less certain.

I. Mangyshlak-Amu-Dar'ya synclinal zone. Ia - Mangyshlak folded zone. Mangyshlak meganticlinorium (1): 1 - Kunya-Urgench projection, 3 - Chashdep projection, 4 - Aybugir anticline; 5 - Eastern Shordzha projection; Northern Mangyshlak basin (2): Southern Mangyshlak basin (3): 12 - Western Butentau anticline; 17 - Kurganchik anticline. Ib - Western Amu-Dar'ya folded zone. Urgench anticlinorium (4): 25 - Kyzylrabat anticline, 26 - Sakcha anticline, 27 - Shavatlyn anticline; Turtkul' synclinorium (5): Khiva synclinorium (6). Ic - Eastern Amu-Dar'ya folded zone.

removed, which under natural conditions occurs in folded regions. Moreover the structural tectonic regionalization, in spite of its being based on the top of the basement, nevertheless reflects not only the structure of the basement surface, but also its internal structure. This is readily seen in the first-order structures, which are considered both as specific structures of the basement surface and as zones in the internal structure of the basement (containing one or two structural stages). This applies in part to structures of the second order as well. For example, the Chimbay basin, located in the axial zone in the northwestern part of the Sultan-Uizdag-Nukus uplift, which is a structure of the second and even of the third order, is at the same time a negative structure in the top of the basement and also a synclinorium (see Figure 1). The upper structural stage of the latter is composed of Late Paleozoic sedimentary formations, and the lower stage of a complex of primarily basic rocks of pre-Upper Devonian age, complicated by a zone of tectonic dislocation.

Analysis of the geophysical data indicates that in the majority of cases the internal structure of the basement is also reflected, with a greater or lesser degree of contrast and completeness, in the structure of its surface. Moreover it must be noted that wherever the structures have been distinguished only from the magnetic and gravimetric survey data, some caution is required in also characterizing them as possible structures of the basement surface. The internal structure of the basement frequently has an important effect on the corresponding indices of magnetic and gravimetric surveys. In the Chimbay basin, out of the total amount of depression of the surface of the basement, as determined from siesmic data, only 20% may be attributed to the observed intensity of the Δg minimum, whereas the remaining 80% is due entirely to the internal structure of the basement. There are apparently even possible cases in which the effect of the internal structure may come even closer to 100%, thus practically obscuring the structures on the basement surface. Thus all the structures distinguished on the tectonic map (see Figure 3) according to magnetic and gravimetric survey data must be confirmed by seismic surveys.

Within the region under consideration one may distinguish five subequatorial structural-tectonic zones of the first order (see Figure 2 and Figure 3): I - the Mangyshlak-Amu-Dar'ya synclinal zones: II - the Buzacha-Zeravshan anticlinal zone; III - the Ustyurt-Kyzylkumy synclinal zone; IV - the Karakumy anticlinal zone; V - the Southern Karakumy zone of depressions.

The Mangyshlak-Amu-Dar'ya first-order structural zone is a distinct syncline in the top of the magnetic rock complex, identified, as indicated above, from the top of the pre-Upper Devonian rocks composing the lower structural stage of the Paleozoic basement. The boundaries of this zone are determined mainly by the position of the above-mentioned top surface. At the same time they are controlled by the maximum values of ΔT_α > 100 gammas associated with the greater part of this zone, by the general minimum values of Δg and by more local maximums in the axial part of the zone, as well as a general depression of the V defracting layer and a decrease in its boundary velocity to 5 km/sec, along with more local uplifts of this layer in the axial part of the zone. This structural zone forms an enormous arch-shaped belt from 120 to 270 kilometers wide and more than 1200 kilometers long, stretching from the Assakeaudan basin and the adjoining part of the Ustyurt to the Aybugir and the Sarykamysh delta of the Amu-Dar'ya River, and thence along the banks of the Amu-Dar'ya River along the southern margin of this region. Beyond the limits of the region under investigation it continues in a subequatorial direction toward the west, along the western end of the Mangyshlak Peninsula, and southward in a submeridional direction as far as Paropamiz.

Chardzhou-Pitnyak anticlinorium (7): 39 - Pitnyak (Dyuyeboyun) anticline; Sadyvar synclinorium anticline (8): Bukhara-Gazhda anticlinorium (9): Eastern Karatokyn synclinorium (10).

II. Buzacha-Zeravshan anticlinal zone. Nukusska-Sultan-Uizdag horst (11): 43 - Khodzheyla anticlina, 44 - Nukusska basin, 45 - Shinkel'aul anticline; Chimbay basin (12): Takhta-Kupyr uplift (13): 69 - Uchtagan anticline, 70 - Bal'dzhan anticline, 72 - Dzhangazasha anticline, 74 - Western Karakumy anticline; Northern Barsa-Kel'messkaya anticlinal structure (14): Baychagyr anticlinal structure (15).

III. Ustyurt-Kyzylkumy zone. a - Northern Ustyurt basin, b - Aral' basin.

IV. Karakumy anticlinal zone. Adzhikuya anticlinorium (16): 78 - Shakh-Senem anticline, 79 - Adzhikuya anticline, 80 - Eastern Kyrkkuya anticline, 81 - Ussamingla anticline; Eastern Akhchakaya synclinorium (17): Eastern Akhchakaya anticlinorium (18): 89 - Eastern Sarykamysh anticline, 94 - Akhchakaya anticline, 95 - Akbashlyn anticline, 96 - Northern Damlyn anticline; Sarykamysh synclinorium (19); Western Sarykamysh anticlinorium (20): 100 - Eastern Assakeaudan anticline, 101 - Kurgankyr anticline, 102 - Southern Sarykamysh anticline, 103 - Akiavat anticline; Verkhne Uzboy-Unguz synclinorium (21); Karashor meganticlinorium (22); 116 - Eastern Assakeaudan anticline, 117 - Karashor meganticline, 118 - Gurtybaba anticline, 120 - Southern Kyrpakkyr anticline, 121 - Kuruk anticline, 122 - Tamderla anticline; Uchtagan synclinorium (23); 131 - Southern Yerbent anticline; Tuarkyr meganticlinorium (24).

V. Southern Karakumy synclinal zone. a - Transcaspian basin, b - Ciskopetdag basin, c - Unguz basin.

The northern boundary of this zone may be drawn approximately along the line which, on the attached map of the structures on the basement surface (see Figure 2), follows the 2-km structure contour line in the south, surrounding the Baychagyr, the Northern Barsa-Kel'mess and the Nukus-Sultan-Uizdag uplifts in the top of the basement. In the east the northern boundary of this zone coincides approximately with the southern boundary of the outcrops of the Paleozoic Zeravshan anticlinal zone, whose westernmost reflection is the Sultan-Uizdag, and in the west follows the northern boundary of the eastern continuation of the Mangyshlak orographic zone (the Karabaur arch). The southern boundary of the zone in the southeastern part of the region approximately coincides with the 3-km structure contour line, and in the northwestern part follows the 4-km structure contour line that surrounds certain separate closed areas. Orographically the southern boundary is approximately determined by the southern boundary of the Assakeaudan basin and the Sarykamysh delta of the Amu-Dar'ya River and by the eastern boundary of the Zaunguzskiye Karakumy.

The Mangyshlak-Amu-Dar'ya synclinal zone is subdivided into three folded subzones: Ia - a Mangyshlak subzone with a subequatorial trend, Ib - a Western Amu-Dar'ya subzone and Ic - an Eastern Amu-Dar'ya subzone with a submeridonal trend.

Within the Mangyshlak folded subzone, the basement has a clear two-stage structure, as established from the data already cited above: 1) the fact that the depth to the top of the magnetic rocks is greater than the depth to the V refracting layer by a factor of two or more; 2) the low boundary velocities of the V refracting layer ($V_b \approx 5$ km/sec) along with the great intensity of the magnetic field, $\Delta T_\alpha > 100$ gammas and in places even > 300 gammas; 3) a minimum Δg forming the background for a maximum Δg in the axial part of the structure; 4) in the Mangyshlak and Aybugir areas, a correspondence between the V refracting layer ($V_b \approx 5$ km/sec) and the top of a thick complex of almost nonmagnetic Permian and Triassic folded molasse deposits. According to these data, the results of the magnetic survey characterize the lower structural stage of the Paleozoic basement, forming a depression, whereas the seismic survey data reflect the upper stage, whose deposits (molasse) fill the depression in the lower stage. As already mentioned, the complex of rocks forming the lower structural stage is of pre-Upper Devonian age and primarily of basic and in places ultrabasic composition, whereas in the southern part of the zone it is of sedimentary-metamorphic composition; the igneous rocks are probably located in the area of a fault. The upper stage, which is Permian-Triassic and in the southern part of the zone is of Carboniferous age, is thickest in the central, axial part of the zone: here the lower structural stage shows the greatest depression, and the upper stage forms an inverted meganticlinorium. The thickness of the upper structural stage in the axial part of the subzone, which may be called the Mangyshlak meganticlinorium, exceeds 10 km in the Mangyshlak, and in the region under consideration it is apparently still greater. Toward the northern and southern boundaries of the Mangyshlak folded subzone the thickness of the upper structural stage decreases to zero.

The Mangyshlak meganticlinorium, as established from the position of the intensive Δg maximum and the uplift of the V refracting layer in the Mangyshlak and in the vicinity of the Sarykamysh delta of the Amu-Dar'ya River, is a comparitively narrow (about 25 km) structure extending in a subequatorial direction for a distance of 720 km, from the Aybugir area in the east to the Mangyshlak Peninsula in the west. The northern and southern limits of the meganticlinorium coincide with the lines marking very large gradients of Δg (on the order of 5 mgl per 1 km), which usually indicate lines of tectonic dislocation. In view of this, as well as the fact that the geologic data indicate that the high Δg gradients are associated with faults in the Permian-Triassic rocks and the platform mantle, both of these boundaries of the meganticlinorium are shown on the map (see Figure 3) as boundaries of a tectonic zone. The Mangyshlak meganticlinorium is apparently an intensively folded structure that has undergone disjunctive dislocations of the nature of reverse faults. The Mangyshlak meganticlinorium contains a number of local anticlinal structures of the third order.

On the north and south the Mangyshlak meganticlinorium is bordered by basins reflected (according to the data from all three geophysical methods) in both stages of the Paleozoic basement. The northern basin will here be called the Northern Mangyshlak and the souther the Southern Mangyshlak basin. The Southern Mangyshlak basin contains both anticlinal and synclinal local structures. Of these, from the standpoint of possible oil and gas occurrences, the most interesting is the Kurganchik anticline, located almost in the center of the Sarykamysh delta of the Amu-Dar'ya river. The Mangyshlak folded subzone is intersected by three transverse faults (see Figure 3).

The Western Amu-Dar'ya folded subzone is divided into three parts: the Urgench anticlinorium in the axial part of the subzone, and the Turtkul' and Khiva synclinoria, which border the Urgench anticlinorium on the east and west. The basement structure in this subzone resembles the structure of the basement surface in the Mangyshlak; in the rest of the subzone, however, it is different. The trend of the Western Amu-Dar'ya subzone is submeridional, and not subequatorial; its axis contains anticlinoria, and not inverted anticlinoria, so that the rocks

of both stages of the Paleozoic basement are conformable. The axial part of the subzone shows no traces of disjunctive tectonic dislocations (a lower ΔT_α field; a Δg maximum of low intensity and no contrast). The upper stage of this subzone, of course, is characterized by a boundary velocity which approaches $V_b \approx 5.5$ km/sec (in the Mangyshlak zone $V_b \approx 5$ km/sec), indicating that the rocks of the upper stage are pre-Permian and are considerably thinner than those in the middle part of the Mangyshlak folded zone.

In the Western Amu-Dar'ya subzone the basement shows a general subsidence toward the south; south of the 39° 40' parallel the composition of the basement rocks changes. There is an undulation of the axes of anticlinoria and synclinoria, forming both positive and negative third-order structures.

The Eastern Amu-Dar'ya folded subzone, which is known in the geological literature as the Bukhara depression, adjoins the Western Amu-Dar'ya subzone on the east, but its basement is elevated and does not contain any of the rocks of the upper (post-Middle Devonian) structural stage. The lower stage is here composed primarily of sedimentary-metamorphic rocks. The rest of the Eastern Amu-Dar'ya subzone resembles the Western; it also shows a predominance of submeridional (northwest) trends of the structural elements, the same linear zonality in the position of the second-order structures — anticlinoria and synclinoria or depressions. The Eastern Amu-Dar'ya subzone from west to east contains the following local and parallel structures: the Chardzhou-Pitnyak anticlinorium, known in the literature as the Chardzhou-Pitnyak zone or the Darganata arch; the Sadyvar synclinorium; the Bukhara-Gazhda anticlinorium, also called the Bukhara-Gazhda zone or the Bukhara arch; and the Eastern Karashoka synclinorium.

The anticlinoria and synclinoria of the above-described Priamudar'ya zones do not merge with the subequatorial structures of the region, which gravitate toward the eastern part of the Sultan-Uizdag, tending to intersect them. For example, the Khiva and Turtkul' basins (synclinoria) are probably associated respectively with the Nukus and Chimbay basins, located north of the former.

Within the Buzacha-Zeravshan anticlinal zone, bordered by the Mangyshlak-Amu-Dar'ya synclinal zone on the north, one may distinguish three more local anticlinal structures with the top of the basement at the levels of the -2 km or -1 km structure contour lines or higher: the Southern Aral' (Nukus-Sultan-Uizdag horst, the Chimbay basin and the Takhta-Kupyr uplift), the Northern Barsa-Kel'mess and the Baychagyr anticlinal structures. West of the Baychagyr anticline lies the Northern Buzacha anticlinal structure, and east of the Southern Aral' anticline is the Zeravshan anticlinal structure.

Along with the structures listed above, the Buzacha-Zeravshan zone contains a number of structures of lesser orders (third and fourth). Thus in the Buzacha-Zeravshan zone the basement is represented primarily by the lower (pre-Upper Devonian) structural stage.

According to the seismic data, in the area of the Nukus-Sultan-Uizdag, Chimbay and Takhta-Kupyr structures the basement surface is at the -1 km level or higher. This area will be called the Nukus-Sultan-Uizdag folded zone. In the southern part it is represented by a block of deposits dislocated primarily in the subequatorial, or Mangyshlak, direction, and in the north by a block dislocated in the submeridional, or Urals, direction. The boundary between these blocks follows the line connecting the Kipchak with the western end of the structure numbered 69. The contact between the blocks is apparently tectonic. Such a contact, although not as clearly, may also be observed in the eastern and northwestern parts of the Sultan-Uizdag, considering the interrelationships of the exposed complexes of Paleozoic rocks.

The Nukus-Sultan-Uizdag horst (essentially a meganticlinorium) according to the above indications is composed of older (Lower Paleozoic) rocks and is bordered by a tectonic contact of the reverse fault type, whose amplitude is 0.3 to 1 km. The position of this contact is clearly fixed from the behavior of the V refracting layer, and is marked by maximum gradients of Δg and intensive narrowly local positive ΔT_α anomalies. According to the seismic data, which agree closely with the gravimetric and magnetic surveys, in the northwestern part of the horst one may distinguish the Khodzheyla anticline (meganticline), the Nukus local basin and the Shinkel'-aul anticline. The Khodzheyla anticline continues in the northwest-by-west direction beyond the horst (as Structure 43a). The Nukus local basin is associated with a deep fault and is, as mentioned above, the northern continuation of the Khiva basin. The Chimbay basin adjoins the Sultan-Uizdag horst on the north, and is the middle part of the Nukus-Sultan-Uizdag folded zone. The middle part of the Chimbay basin is complicated in the north by an uplift, thus forming the Western Chimbay and the Eastern Chimbay synclines. The latter is composed of Upper Paleozoic rocks and coincides with a deep fault zone, which supposedly defines the northern continuation of the Khiva depression. The Chimbay basin lies immediately north of the Sultan-Uizdag horst; the former is the central part of the Nukus-Sultan-Uizdag folded zone. The central part of the Chimbay basin is complicated by an uplift in the north, forming the Western and Eastern Chimbay synclines. The latter is composed of Upper Paleozoic rocks and coincides with a deep fault zone which

supposedly defines the northern continuation of the Turtkul' basin. The Takhta-Kupyr uplifts adjoins the Chimbay basin on the northeast.

The Northern Barsa-Kel'mess anticlinal structure, as distinguished by the magnetic survey data, is apparently a fairly complex folded zone. It is bordered by faults on the west and east, and in the middle is broken by a transverse fault trending northeastward. In its general features the Northern Barsa-Kel'mess anticline apparently resembles the Baychagyr anticlinal structure.

The Buzacha-Zeravshan anticlinal zone (Zone II) is bordered on the north by the Ustyurt-Kyzylkumy synclinal zone (Zone III), within which the top of the basement occurs at -3 km or below. The northern border of Zone II (the southern boundary of Zone III) has been tentatively drawn along the above-mentioned structure contour line at -3 km and according to the above observations on the composition of the basement. The Tectonic Map of the USSR [10, 11] shows the Northern Ustyurt basin at the extreme western end of the area distinguished here as Zone III, and the Northern Kyzylkumy basin at the extreme east. Thus it is proper to call Zone II the Ustyurt-Kyzylkumy synclinal zone. Within these one may distinguish the Northern Ustyurt basin and the Aral' depression; the boundary between these is shown tentatively.

The Karakumy anticlinal zone (Zone IV) is a complex folded system consisting of parallel alternating anticlinoria and synclinoria, or basins. In the north their trend is northwestward (NW 30°), like the Tuarkyr, and in the south it is first subequatorial, approaching the trend of the Kopet-Dag, and then again changes to northwestward. The anticlinoria and synclinoria are indistinct in the eastern part of the zone but become more clearly distinguishable in the western part. They appear to surround a certain body, like the magnetic ΔT_α anomalies which characterize the trend of the lithologic-petrographic complexes in the lower stage; both are characterized by areas of ancient consolidation, such as the Karakumy anticlinal zone in certain areas. The lesser contrast between the anticlinoria and synclinoria in the eastern half of the zone is probably due to the fact that they underwent a lesser degree of rejuvenation in the latest orogenic cycle. On the north and east this zone is bordered by the Mangyshlak-Amu-Dar'ya synclinal zone, and on the south by the Southern Karakumy synclinal zone.

The Karakumy anticlinal zone contains (from east to west) the following second-order structures: the Adzhikuya anticlinorium (16); the Eastern Akhchakaya synclinorium (17), the Eastern Akhchakaya anticlinorium (18), the Sarykamysh synclinorium (19), the Western Sarykamysh anticlinorium (20), the Verkhne-Uzboy-Unguz synclinorium (21), the Karashor meganticlinorium (22), the Uchtagan synclinorium (23) and the Tuarkyr meganticlinorium (24). The origin of structure (16), the northern parts of structures (17) and (18), and structures (19) and (20) in the east and of structure (24) in the west, is due to Early Paleozoic (perhaps Precambrian) movements, and that of structures (21) and (23) is associated with Middle Devonian and in a small area with Permian-Triassic folding.

The anticlinoria and synclinoria in the Karakumy anticlinal zone, without changing their trend, seem to merge into the Southern Mangyshlak basin in the north and into the Southern Karakumy synclinal zone in the south. These second-order structures contain more local third-order and fourth-order structures.

The Southern Karakumy synclinal zone, which borders the Karakumy anticlinal zone on the south, is subdivided into the Transcaspian basin, the Ciskopetdag basin and the Unguz basin. The northern boundary of the Southern Karakumy basin approximately follows the -5 km structure contour.

A comparison of the structural-tectonic diagrams shown here (Figure 2, 3) with the more regional Tectonic Map of the USSR [10, 11] suggests that the Buzacha-Zeravshan anticlinal zone may be linked with the Voronezh crystalline massif, the Mangyshlak subzone with the Donets Basin, the Karakumy anticlinal zone with the Ukrainian (Azov) crystalline massif, and the Southern Karakumy zone of depression with the Ciscaucasus basin.

REFERENCES

1. Belousov, V.V., Osnovnyye voprosy geotektoniki. [FUNDAMENTAL PROBLEMS OF GEOTECTONICS]: Gosgeoltekhizdat, Moscow, 1954.

2. Garetskiy, R.G. and V.I. Shraybman, O glubinnom stroyenii Severnogo Ustyurta i vozmozhnom proiskhozhdenii yego tsinkov. [ON THE DEEP STRUCTURE OF NORTHERN USTYURT AND THE POSSIBLE ORIGIN OF ITS ZONC ORES]: Izvestiya Akademii Nauk SSSR, ser. geofiz., no. 12, 1956.

3. Garetskiy, R.G., Geologicheskoye stroyeniye i perspektiva neftenosnosti yuzhnogo pogruzheniya Mugodzhar. [THE GEOLOGIC STRUCTURE AND THE PROSPECTS FOR OIL OCCURRENCES OF THE SOUTHERN PLUNGE OF THE MUGODZHARY]: Geologiya nefti, no. 1, 1958.

4. Geologiya SSSR, tom XXII, Turkmenskaya SSR, ch. 1, geologicheskoye opisaniye. [THE GEOLOGY OF THE USSR, VOL. XXII, THE TURKMEN SSR, PART I,

GEOLOGIC DESCRIPTION]: Gosgeoltekhizdat, 1957.

5. D'yakov, B. F., Skhema tektonicheskogo stroyeniya i perspektivy neftenosnosti p-ova Mangyshlak. [THE TECTONIC STRUCTURE AND PROSPECTS FOR OIL OCCURRENCES OF THE MANGYSHLAK PENINSULA]: Geologiya nefti, no. 7, 1957.

6. Zhukovskiy, L. G. and V. D. Il'in, Osnovnyye voprosy tektoniki i perspektivy neftenosnosti Bukharo-Khivinskoy depressii. [CHIEF PROBLEMS OF THE TECTONICS AND OIL PROSPECTS OF THE BUKHARA-KHIVA DEPRESSION]: Geologiya nefti, no. 7, 1957.

7. Kasatkin, D. P., O nekotorykh rezul'tatakh geofizicheskikh issledovaniy v Severnoy Turkmenii. [SOME RESULTS OF GEOPHYSICAL INVESTIGATIONS IN NORTHERN TURKMENIA]: Razvedka i Okhrana Nedr, no. 6, 1955.

8. Kasatkin, D. P., Opyt vydeleniya lokal'nykh gravitatsionnykh anomaliy v Severnoy Turkmenii. [AN ATTEMPT TO DISTINGUISH LOCAL GRAVITATIONAL ANOMALIES IN NORTHERN TURKMENIA]: Razvedka i okhrana nedr, no. 6, 1957.

9. Sungurov, A. M., Glubinnaya struktura Pitiyaskogo rayona po dannym geofizicheskikh issledovaniy i perspektivy yego gazonosnosti. [THE DEEP STRUCTURE OF THE PITIYASKIY DISTRICT ACCORDING TO GEOPHYSICAL DATA AND ITS GAS-BEARING PROSPECTS]: Geologiya nefti, no. 1, 1958.

10. Tektonicheskaya karta SSSR i sopredel'nykh stran v masshtabe 1:5,000,000. [A TECTONIC MAP OF THE USSR AND ADJACENT COUNTRIES ON THE SCALE OF 1:5,000,000]: Gosgeoltekhizdat, 1956.

11. Tektonicheskaya karta SSSR i sopredel'nykh stran v masshtabe 1:5,000,000. [A TECTONIC MAP OF THE USSR AND ADJACENT COUNTRIES ON THE SCALE OF 1:5,000,000]: Gosgeoltekhizdat, 1957.

A GENERAL ESTIMATE OF THE WORLD'S COAL RESOURCES[1]

by

G.V. Korotkov[2]

REVIEWER'S NOTE

Of general interest, although little specific data are given. Probably wide general reader interest.

ABSTRACT

A comparative estimation of coal reserves for the foreign countries and the USSR is given. It emphasizes the existence of considerable variations in quantitative coal reserve estimations of the foreign countries in consequence of the absence of a unitary method of coal resource estimation. It is necessary therefore to estimate world coal reserves in accordance with the unitary method as it was done in 1913 and 1956 (USSR). --auth. English summ

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The coal resources of the entire earth were first computed by a unified method in 1913, on the occasion of the XII International Geological Congress (in Toronto). As is known, these resources (actual, probably and possible, computed to the depth of 1,800 m) amounted to 7397 billion metric tons, of which 2998 billion were rock roal. Coal seams varying in thickness from 0.3 to 1,200 m and from 0.6 to 1,800 were considered. The resources of Russia amounted to 234 billion metric tons, or 3.2% of the world's total. New computations for all the countries of the world have not since been made.

On the occasion of the XVII International Geological Congress (in Moscow) the coal resources of the U. S. S. R. and certain other countries were again computed, using the standards employed in 1913. The U. S. S. R. 's coal resources according to this calculation had risen to 1654 billion metric tons (of which 1,325 billion were anthracite and bituminous) and formed about 21% of the world's total coal resources.

After 1937 attempts were made to estimate the total extent of the world's coal basins, but this work was actually organized and executed only in the U. S. S. R., where the coal resources were again recomputed in 1956, on the basis of the criteria of 1913 and 1937. The net coal resources (conditional according to thickness and ash content) of the U. S. S. R.[3] amounted to 7,765 billion metric tons, 4,504 billion being rock coal.

At the present time it is impossible to establish the absolute magnitude of the world's coal resources, since in a number of countries, some of which posses the greatest coal resources, new local estimations of coal resources have been made in the period from 1948 to 1957; these estimates have been made by various methods, without following the criteria and methods used earlier.

For the most part, there has been a tendency to decrease the estimates of coal resources by decreasing the depth to which the computation is made and raising the lower limit for the thickness of a workable coal seam. For example, the depth to which the coal resources were computed in the U. S. A. was decreased to 900 m (and according to some sources even to 600 m), in Canada to 300 - 750 m, and in certain European countries (such as the German Federal Republic, France and Belgium) to 1200 m. There has also been a tendency to depart from computations of "possible" resources, since this conception, like the "probable" and "actual" reserves, is given different meanings in different countries. The minimal thickness for computing a workable coal seam was increased in Canada to 0.9 m and in the U. S. A. to 0.6 - 0.7 m.

The principal changes in the world's geological reserves of coal in recent years have been due to the discovery of enormous and earlier unknown new basins and coal districts in the U. S. S. R. and China. It is enough to say that the resources of China, which in 1913 were estimated at 996 billion metric tons, because of the poor state of knowledge of the geology of this enormous territory, later began to be reckoned as much less (on the order of 300 - 400 billion metric tons). In recent years, however, extensive geologic investigations have been undertaken in the Chinese People's Republic and the estimate of its coal reserves has been raised sharply.

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[1]Translated from Sovetskaya Geologiya, 1960, no. 1, p. 72-74.

[2]Mining Institute of the Academy of Sciences of the USSR.

[3]Zapasy ugley i goryuchikh slantsev SSSR (Coal and coal shale resources of the USSR): Gosgeoltekhizdat, 1958.

At the present time there are still no official data on the coal resources of China. As early as 1950, however, these had been reckoned at 1, 011 billion metric tons, and later these data were revised upward to 4, 000 billion; the Ministry of Coal Industry of the Chinese People's Republic in 1958 published a still higher estimate, which, however, requires corrections. According to the goals for the five-year plan for 1959, as published by the Central Statistical Administration of the Chinese People's Republic, the surveyed coal reserves in categories $A_2 + B + C_1$ are 150 billion metric tons and the prospective reserves are 1, 500 billion tons.

It is clear from what has been said above that no estimates of the world's coal reserves have been made according to any unified method or principle. At this time one can only make a general guess at these reserves in the various countries, with a tentative summation and comparison of these estimates.

The figures for such an attempted summation are cited below. On the basis of data published in 1958 in the technical literature of Belgium and Germany,[4] the coal resources of countries outside the Soviet Union as estimated at present may be given as below (in comparison to those of 1913):

mind that the figures for the coal resources of the Soviet Union are absolute, reflecting the totality of all possible coal reserves in the depths, so that the total geological coal reserves of the U. S. S. R. are not now comparable to the reserves of the majority of other countries which have very large coal resources. The amounts in such countries are relative, determined according to various definitions of the conception "coal reserves" in the different countries, variously combined and even influenced by political considerations.

Nevertheless some comparison may be made of the coal reserves of the U. S. S. R. and of other countries, on the basis of the depths to which the computations have been made in the countries of the world, since the depth is obviously a basic factor in computing coal reserves. The various thicknesses of the workable coal seam taken as the norm are also a factor, of secondary importance, (apart from the exception of Canada); for example, in computing the U. S. S. R. 's coal reserves in 1937 it was determined that the amount of coal included in very thin seams (0. 3 - 0. 5 m thick) and now not taken into account in a number of countries came to only 1. 6% of the total reserves.

Part of world	Coal reserves, in billion metric tons		
	1913	1950 - 1957	Change in estimate
America	5, 105	2, 410	-2, 695
U. S. A.	3, 839	2, 142	-1, 697
Canada	1, 234	113	-1, 121
Europe	724	621	- 103
Asia	1, 106	1, 580	+ 474
China	996	1, 500	+ 504
Oceania	170	54	- 116
Africa	58	75	+ 17
TOTALS	7, 163	4, 740	-2, 422

These data show that the estimate of the world's coal reserves has decreased sharply, at the expense of two countried — the United States and Canada (by the amount of 2, 818 billion metric tons).

In moving on to an estimation of the coal reserves in the U. S. S. R., it must be borne in

On the basis of the fact that the countries which in 1913 were estimated to have the greatest coal reserves in the world — the U. S. A. and Canada — now compute their reserves to the depth of only 900 m or even less, and in a number of countries of Europe the calculations are limited to depths of the order of 900 - 1200 m, within the total resources of the U. S. S. R. we may distinguish those portions that fall into the depth categories above (900 - 1200 m). A comparison gives the following results (in billions of metric tons):

[4] Annales des mines de Belgique, II, 1958. Braunkohle waerme unf energie, XII, 1958.

Reserves of other countries	Reserves of the USSR	
	to depth of 900 m	to 1200 m
4, 252	4, 959	6, 229

Taking the reserves of the U.S.S.R. down to the depth of 900 m as the more comparable magnitude, one may conclude that the world's total coal reserves down to this depth amount to approximately 9, 000 billion metric tons, and that those of the Soviet Union are about 50% of the world's total, as compared to 21% in 1937 (taking the coal resources of China to be 1, 500 billion metric tons).

The extent to which the question of a total and and reliable estimate of the coal reserves in the various countries is complicated because of the lack of a unified method and basis for computation may be seen from the following example. According to data provided by Belgian scientists (Lardinnois, 1958), the limits of fluctuation of the estimates of coal resources — both of the world and of individual countries — are extremely great. For example, the total world's coal reserves (without the U.S.S.R.), according to a summation of the minimal estimates, amount to 2, 873 billion metric tons of anthracite and bituminous coal and 882 billion metric tons of brown coal, whereas the maximal totals are 8, 515 billion and 2, 780 billion respectively.

For the individual countries of the world, these fluctuations between the minimal and maximal estimates may be seen from the following figures (in billion metric tons).

For the remaining countries of the world, the discrepancies between the minimum and maximum estimates of their coal reserves are not as great.

It is clear that a new and consistent international computation of the world's coal resources according to unified standard principles, such as was made in 1913, has long been needed.

	Bituminous coal and anthracite	Lignite (brown coal)
USA	1, 260 - 1, 958	420 - 1, 925
South America	15. 7 - 38. 7	28 - 71
Europe (minus USSR)	257 - 672	138 - 175
German Federal Republic	123 - 208	56 - 65
German Democratic Republic	0. 02 - 0. 225	49 - 50
Belgium	2. 8 - 5. 9	—
Spain	3. 5 - 8. 0	0. 7 - 1. 5
France	5. 73 - 14. 0	0. 30 - 0. 41
England	41 - 224	0. 3
Poland	71 - 135	0. 97 - 9. 8
Saar	2. 8 - 4. 6	—
Asia (minus USSR)	264 - 4, 107	2. 73 - 8. 19
China	250 - 4, 000	1. 0 - 2. 8
Japan	6. 79 - 16. 8	0. 066 - 0. 39
Africa	73. 2 - 221	0. 200 - 0. 3

CONCERNING THE NATURE OF THE ORGANIC MATTER IN THE LOWER CAMBRIAN LAMINARITES CLAYS[1]

by

A.I. Ginzburg and M.M. Tolstikhina[2]

REVIEWER'S NOTE

Good petrographic description of the thin section appearance of organic matter in claystones. Conclusions may have some bearing on evolution and chronology of the higher plants.

ABSTRACT

Disseminated organic components of Lower Cambrian Laminarites clays are identified in thin section as the decomposed ligno-cellulosic and lipoid structure of plants higher than algae, indicating an earlier appearance of psylophytes than Devonian as heretofore assumed. --M. Russell.

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A study of the oldest part of the sedimentary mantle from deep drill cores in the Ryazan-Saratov basin has revealed, in a Lower Cambrian series of Laminarites clays, a pack of gray and bluish-gray flat-bedded rocks consisting of very thin alternating clay and siltstone layers highly enriched in organic matter in the bedding planes. This pack may be readily discerned in the Morsovo, Mosolovo and Kaverino sections. In all three drill cores it is underlain by a pack of reddish and chocolate-brown argillites, which the present writers have assigned to the bottom of the Valday complex (the Lower Cambrian Gdovskiye beds). The argillites in turn overlie a tuffaceous-sedimentary series which we have correlated with the Volhynian complex in Belorussia [1].

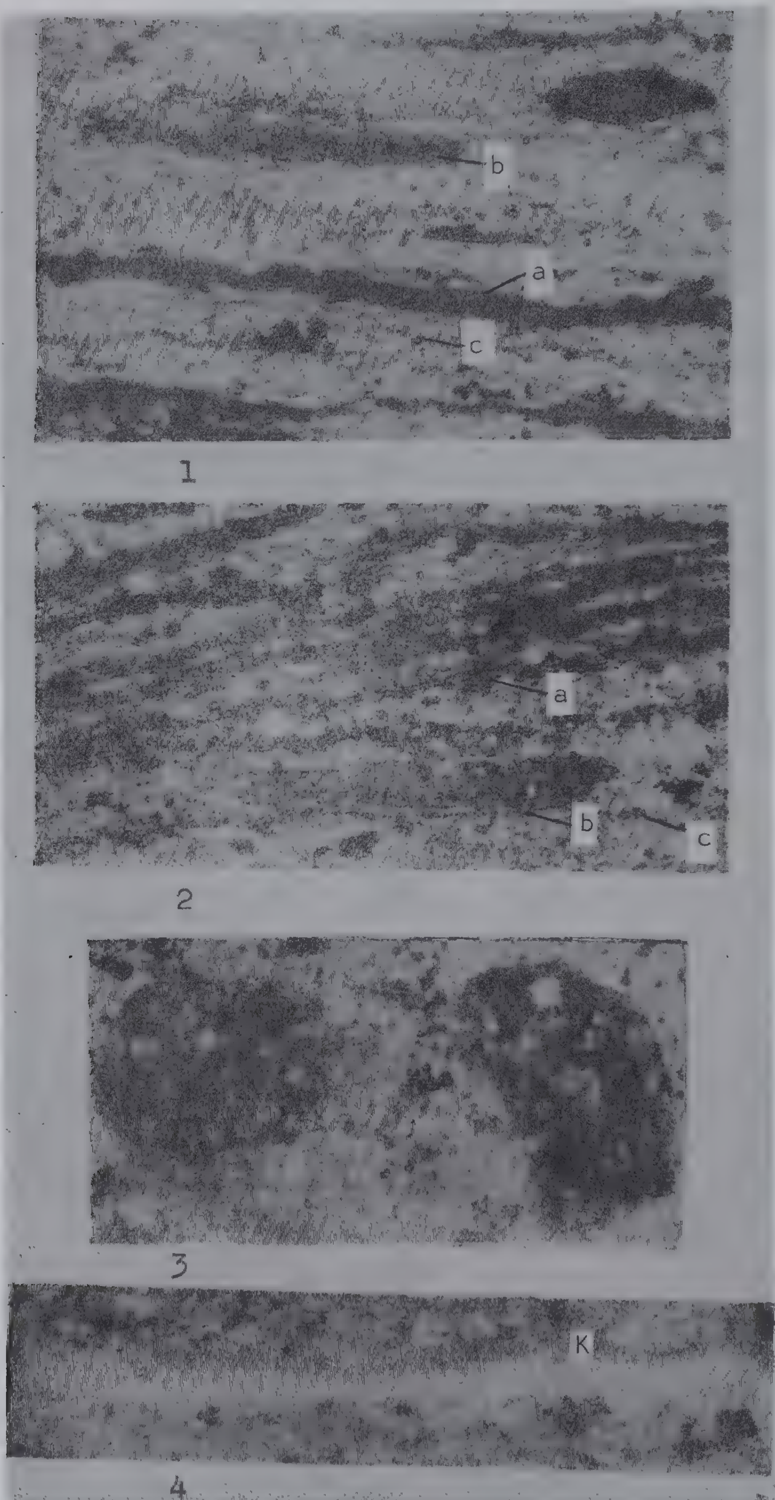
Stratigraphically above the Laminarites clays lies a series of alternating fine-grained sandstones, siltstones and clays, which we have assigned to the base of the Baltic complex (the super-Laminarites beds). Thus this pack of rock layers has a very definite position in the section and its attribution to the Lower Cambrian Laminarites beds is established beyond doubt. Other investigators [3, 4] have come to the same conclusion. Organic matter has been found for a long time in the Laminarites clays. According to its mode of occurrence in the rocks it is of two types: a) thin brownish elastic films in the bedding planes, and b) dispersed inclusions that can be seen only under the microscope. The organic films have been studied in detail [5, 6, etc.]. The authors have concluded that these formations are brown algae of the genus Laminarites. The name of the lower series of the Cambrian clays in the Baltic region is taken from these algae. It is interesting to note that in the Kuznets Basin, the Barzass psylophytes were also described earlier as brown algae. The dispersed organic inclusions have not been specially studied; there are only some indications [5] that they contain humic acids.

The object of our investigations was the scattered organic remains in the Laminarites silty clays of the Morsovo, Mosolovo and Kaverino areas. Detailed microscopic study of these formations has shown that in their color, outlines, optical properties and distribution they very closely resemble the carbonized and highly altered plant remains of the psylophyte group, whose composition includes ligno-cellulosic matter. In some specimens the carbonized organic inclusions are distributed strictly along the bedding planes, forming horizontal layering. The alternating layers of light-gray clay and dark-gray carbonaceous matter are very thin. The thickness of the clay layers is 2 to 3 mm, and that of the carbonaceous layers is 1 to 2 mm; there are also some other relationships (Figs. 1 and 2). The thin and strictly horizontal layering in its general appearance resembles that of varved clays.

Under the microscope, in the vertical section, the interlayers of organic components consist primarily of orange-red and brownish-red structureless formations (Fig. 1, 2a). In some parts they apparently occur in very fine dispersed mixture with clay matter. In the brownish-red mass, and sometimes directly in the silty clay, there are sometimes elongated small lenses up to several milimeters long, or fragments which do not have rounded edges. These have a bright red, orange-yellow and yellow color and a homogeneous structure (Figs. 1, 2b, 3). Under crossed nicols in polarized light all the described formations are very slightly anisotropic, and in some cases they show secondary structure, like ordinary coal; the light interference is very low.

In thin sections prepared in the bedding planes, the brownish-red organic substance shows a spotty distribution and, like the clay, contains bodies with very rounded outlines and a red or orange color. Even under high magnification their structure is not clear (Fig. 4).

[1]Sovetskaya Geologiya, 1960, no. 1, p. 126-129.
[2]All-Union Scientific Research Institute of Geology.



Figs. 1 - 4. Thin sections, magnification X 200:

1 and 2 - vertical sections: a - brownish-red structureless gelified matter, b - orange-yellow formations resembling cuticle, c - pyrite; 3 - vertical section; K - yellow cuticle; 4 - horizontal section, showing brownish-red rounded gelified formations resembling sclerotium.

The yellow inclusions in the horizontal section represent a film with a scarcely discernible outline, resembling the traces of large cells.

A comparison of the organic formations found in the Laminarites clays with the organic part of the usual humic coals suggests the following analogies:

1. The brownish-red and red interlayers that form the fine banding are almost exactly like the usual gelified groundmass in coal.

2. Some of the red lenses occurring in the basic organic mass, and also directly in the clay, in their color and outlines resemble vitrain (Fig. 2).

3. The long yellow structureless fragments or films in the horizontal thin sections show a similarity to cuticle, and the oval orange and yellow bodies apparently have the same nature as the layer of cuticle.

4. The rounded orange and brownish-red formations most closely resemble gelified bodies of unclear nature, which some coal petrographers have called sclerotium (Fig. 4).

Thus in their color and their manifestations all the above-described organic components have their analogs in humic coals, so that they can be compared to the microcomponents forming the Lower Devonian coals of the Barzass deposit. In the latter, however, the conditions were more favorable to the preservation and accumulation of the cuticle layer. In our case the cuticle-like formations were preserved only as isolated fragments, both in the gelified groundmass and directly in the clay. As regards the soft parts of these plants, most of them might have been transformed into the structureless groundmass, and only a small part into the lenses and fragments of vitrain. A confirmation of this may be found in V. A. Uspenskiy's mention [5] of the content of humic acids in organic matter of this nature. The high degree of decomposition of the original plants is indicated by the numerous tiny grains of pyrite occurring in the organic fraction studied by us.

All that has been said above suggests that the disseminated organic components occurring in the Laminarites clays apparently have nothing in common with the usual sapropel matter derived from the simple algae. They are more likely the decomposed remains of higher plants, whose structure included ligno-cellulosic and lipoid substances.

From this one may conclude that the plants of the psylophyte type may have made their first appearance not in the Devonian, as is usually assumed, but considerably earlier.

REFERENCES

1. Bruns, Ye. P., Stratigrafiya drevnykh doordovikskikh otlozheniy zapadnoy chasti Russkoy platformy [STRATIGRAPHY OF THE ANCIENT PRE-ORDOVICIAN DEPOSITS IN THE WESTERN PART OF THE RUSSIAN PLATFORM]: Sovetskaya geologiya, No. 59, 1957.

2. Yergol'skaya, Z. V., Novyye dannyye o proiskhozhdenii barzasskikh ugley [NEW DATA ON THE ORIGIN OF THE BARZASS COALS]: Khimiya tverdogo topliva, vyp. 1, 1934.

3. Ivanova, Z. P., ed., Nizhnepaleozoiskiye otlozheniya tsentral'nykh oblastey Russkoy platformy [THE LOWER PALEOZOIC DEPOSITS OF THE CENTRAL REGIONS OF THE RUSSIAN PLATFORM]: Gostoptekhizdat, 1957.

4. Postnikova, I. Ye., Dissertation, 1956.

5. Uspenskiy, V. A., A. I. Gorskaya and A. S. Chernysheva, O prirode laminaritov kembriyskikh glin Pribaltiki [ON THE NATURE OF THE LAMINARITES IN THE CAMBRIAN CLAYS OF THE BALTIC REGION]: Geokhimicheskiy Sbornik, No. 2-3, 1951.

6. Eykhval'd, E., Paleontologiya Rossii. Drevniy period [PALEONTOLOGY OF RUSSIA. EARLY PERIOD]: St. Petersburg, 1864, p. 66.

GEOTHERMAL DEEP-WELL LOGGING IN THE OMSK AREA[1]

by

G. Ye. Ryabukhin and I.I. Nesterov

REVIEWER'S NOTE

Contains some very interesting data.

ABSTRACT

Logs of temperature of water in deep wells and isothermal charts derived from them are used to trace the movement of groundwater in the Omsk area. The method is based on observations that rocks with a stable water regime have similar geothermal conditions. In rocks with a dynamic groundwater regime the geothermal interval increases, relative to average magnitude, in structural depressions and decreases in structural elevations. -- M. Russell

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Geothermal observations are pare of the required program of investigation in drilling deep stratigraphic test wells. From these one can study the temperature regime of the earth's crust. Geothermal observations are also valuable material for the solution of problems connected with the migration and genesis of oil and gas.

In 1955 - 1956 the authors of the present article, in connection with their study of the geologic material on the Bol'sherech'ye stratigraphic test well located some 190 km north of Omsh, investigated the geothermal features of the area between the Irtysh, Om' and Tara Rivers. In this area, which occupies the south-central part of the Western Siberian Lowland, geothermal observations were made in the Bol'sherech'ye, Sargatka, Omsk and Tatarsk deep test wells (Fig. 1). These studies were made with the electrical thermometer constructed by the Grozneftegeofizika Trust. The results are shown in Table 1.

The geothermal data cited in Table 1 and the geologic section constructed through the above-mentioned test wells suggest a number of conclusions regarding the movement of ground waters within the south-central part of the Western Siberian lowland. The correct solution to this problem will be of great practical value in determining the direction of migration of oil and gas, which must be taken into consideration in constructing forecasting maps for oil and gas occurrence. For the sake of visual clarity, the data on the distribution of the temperatures in the deep test wells cited in Table 1 has been shown in the form of a teoghermal profile (Fig. 2). There is a clear connection between the behavior of the geoisotherms and the Mesozoic structure along the profile. From north to south there is a gradual subsidence of the Mesozoic rocks. In the Bol'sherech'ye test well, directly above the basement, lie the varicolored deposits of the upper part of the Middle Jurassic (the Tatarian suite), which were discovered at depths of 2551 to 2668 m.

According to the seismic observations, on the flanks of the Bol'sherech'ye structure, in the crest of which was drilled the single deep test well, the section of rocks between the basement and the Upper Jurassic increases to 80 m — that is, on the flanks of the Bol'sherech'ye uplift, beneath the varicolored deposits of the Tatarian suite, we can assume the existence of Middle Jurassic coal-bearing strata.

South of Bol'sherech'ye, in the Sargatka test well 1-R, the section through the lower part of the Mesozoic deposits, beneath the rocks of the Tatarian suite, contains Jurassic coal-bearing sediments represented by an alternation of argillites, siltstones, sandstones, gravelites and conglomerates. These rocks were revealed by drilling in the depth interval from 2786. 2 to 2492 m, whereas the sediments belonging to the Tatarian suite lie at depths of 2492 to 2389 m. The coal-bearing formations encountered in the Sargatka test well 1-R are characterized by a gradual increase, from top to bottom, in the granulometric composition of the rocks.

In the Omsk test well 1-R there is a further increase in the section through the lower part of the Mesozoic, testifying to the subsidence of the basement. In the Tatarsk test well 1-R the basement is encountered hypsometrically 238. 5 m higher than in the Omsk test well. Overlying the rocks of the basement is a 359-meter sequence of Middle Jurassic rocks, of which the varicolored fraction is only 77 m.

A very similar picture of the hypsometric distribution of the stratigraphic horizons along the Bol'sherech'ye—Omsk—Tatarsk profile is observed up to the Upper Cretaceous. Above this their behavior changes, with an increase in thickness in the area of the Tatarsk exploratory test wells.

[1]Sovetskaya Geologiya, 1960, no. 1, p. 129-134.

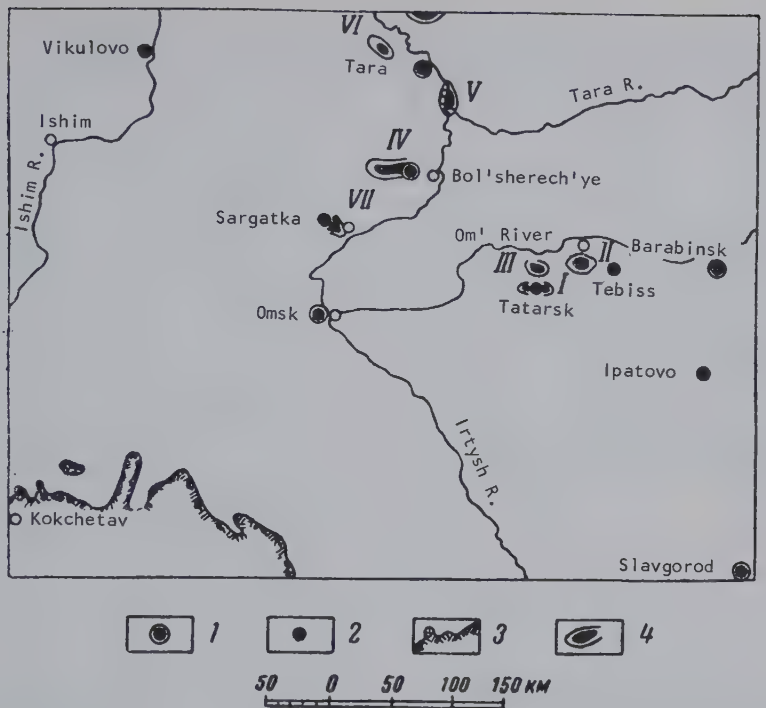

FIGURE 1. Overall map showing the southern part of the Western Siberian Lowland:

1 - exploratory test wells, 2 - prospecting test wells, 3 - line marking the boundary of the exposed basement of the lowland, 4 - local structures (I - Tatarsk, II - Krasnov, III - Ust'-Tark, IV - Bol'sherech'ye, V - Novo-Loginov, VI - Lozhnikov, VII - Sargatka).

TABLE 1

Depth in m	Temperature in test wells in °C				Depth in m	Temperature in test wells in °C			
	Bol'sherech'ye 1-R	Sargatka 1-R	Omsk 1-R	Tatarsk 1-R		Bol'sherech'ye 1-R	Sargatka 1-R	Omsk 1-R	Tatarsk 1-R
300	13.8	—	19.9	13.9	1 500	52.0		46.8	43.2
400	16.2	—	22.0	16.0	1 600	53.5		49.0	45.1
500	19.8	22.5	23.8	18.3	1 700	56.4		51.1	47.0
600	22.6	25.6	25.9	20.8	1 800	59.9		53.7	48.9
700	25.8	28.5	28.1	23.5	1 900	63.2		55.7	50.5
800	28.6	31.5	30.5	28.0	2 000	68.3		58.0	52.3
900	32.2	35.7	32.9	30.8	2 100	72.6			53.9
1 000	35.7	37.9	35.7	32.4	2 200	77.0			55.5
1 100	38.8	41.5	38.5	35.5	2 300	80.4			57.2
1 200	41.5	45.7	40.5	38.2	2 400	84.5			
1 300	44.0		42.5	40.3	2 500	88.7			
1 400	46.9		44.8	41.3	2 600	94.0			

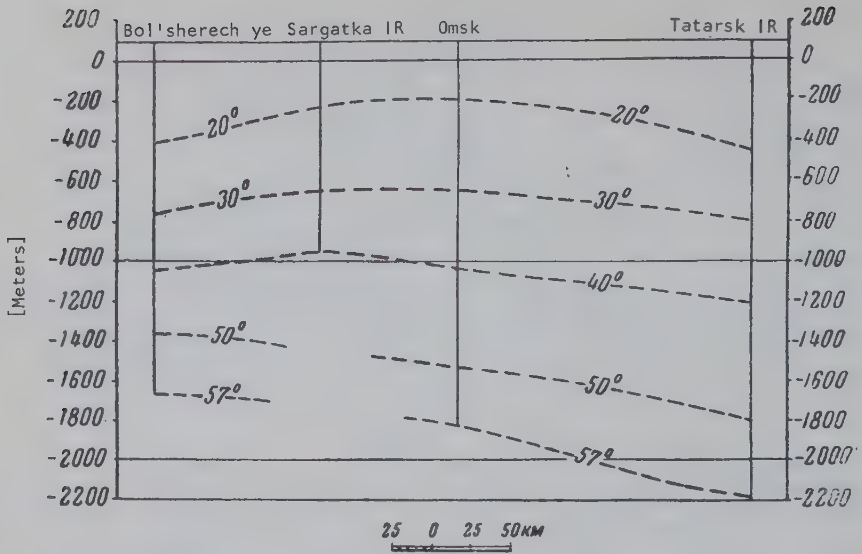

FIGURE 2. Geothermal profile along the Bol'sherech'ye — Sargatka — Omsk — Tatarsk line.

The behavior of the geoisotherms (see Fig. 2) is approximately the same as that of the structure contours. In the geoisothermal profile it will be readily seen that in the lower part of the section the temperatures rise with the higher occurrence of the basement.

In the Bol'sherech'ye drill hole 1-R the 57° geoisotherm occurs at the depth of 1711 m, whereas in the Omsk well it decreases to 1960 m. In the Tatarsk test well 1-R the 57° geoisotherm is encountered at the depth of 2270 m.

The geothermal intervals calculated by us in these test wells also confirm the regular association between the temperature changes and the Mesozoic structure. Table 2 shows the geothermal intervals and gradients calculated for the depths from 300 to 1000 m, and from 1000 to 2000 m.

Comparing the values of the geothermal intervals, as cited in Table 2, with the data on the oil occurrence of the platform regions of the U. S. S. R., it will be concluded that the geothermal intervals there are considerably greater. In Bashkiriya the geothermal interval is 82.6 m, in the Perm region it is 88.2 m, and in the Samar Luka area it is 64.3 m.

It will be seen from Table 2 that the magnitude of the geothermal interval increases from Bol'sherech'ye to Omsk and beyond to Tatarsk. The regular change in temperatures along the Bol'sherech'ye—Omsk—Tatarsk profile, which is associated with the depth at which the basement occurs, is broken only in the vicinity of the Tatarsk exploratory test wells. This anomalously high geothermal interval is apparently due to the more intensive movement of the stratal waters in this area as compared to the

TABLE 2

Test well	Average temperature at depth of 1000 m., °C	In interval from 300 m. to 1000 m. depth		Average temperature at depth of 2000 m., °C	In interval from 1000 m. to 2000 m. depth	
		Average geothermal interval per 1 °C	Average geothermal gradient		Average geothermal interval per 1 °C	Average geothermal gradient
Bol'sherech'ye 1-R	35.7	31.9	3.1	68.3	30.6	3.26
Sargatka 1-R	37.9	38.9	2.5	---	---	---
Omsk 1-R	35.7	44.8	2.2	58.0	44.7	2.2
Tatarsk 1-R	32.4	49.4	2.0	52.3	51.2	1.9

Average geothermal interval is 41.6 m. (between the depth of 300 m. and 2000 m.)

adjacent districts. In the vicinity of Tatarsk there is apparently a constant inflow of cold waters from the folded Paleozoic margin of the lowland. These waters, in cooling the rocks, increase the magnitude of the geothermal interval. For a clearer representation of the relationship between the change in temperature and the ground-water regime, we have computed the magnitude of the geothermal interval for the aquifer in the Aptian—Albian—Cenomanian deposits. The results obtained confirm the notion that the water moves from south to north. Consequently from Bol'sherech'ye to Sargatka and Omsk the geothermal interval, as computed for the aquifer in the Aptian-Albian-Cenomanian, increases from 33. 9 - 34. 3 m to 46. 1 m. In the Tatarsk test well 1-R, the geothermal interval in this water-bearing stratum is 49. 4 m.

The movement of the ground waters in the south-central part of the Western Siberian Lowland may be represented diagramatically as follows. Cold, slightly mineralized waters from the source area, located within the southern folded margin of the Lowland and the adjoining territories, moves toward the less elevated parts of the Mesozoic deposits in the region of the Kulunda Steppe. The axis of this subsidence is apparently located somewhat to the west of Tatarsk. As they descend, the ground waters are heated in cooling the surrounding rocks. Hence the geothermal interval in the Tatarsk test well 1-R is 49. 4 m. This coincides with the value of the geothermal interval computed for the water-bearing stratum in the Aptain—Albian—Cenomanian deposits, indicating that the ground waters penetrate through the entire section of the Mesozoic and Cenozoic in the vicinity of Tatarsk. As the waters move farther northward from Tatarsk they enter a zone of deep subsidence, whose center has been described along the right bank of the Irtysh River, between the Om' and Tara Rivers. Here the waters become heated and, in moving to the structurally uplifted areas, raise the temperature of the surrounding rocks and thus also correspondingly decrease the geothermal interval. In fact, the magnitude of the geothermal interval along the Omsk—Bol'sherech'ye line decreases from 44. 8 m at Omsk in the north to 31. 9 m at Bol'sherech'ye. There is a similar east-to-west decrease in the geothermal interval, from 49. 4 m in the Tatarsk test well 1-R to 44. 8 m at Omsk.

The conclusion that the ground waters move from the south to the north and northwest is supported by the data from hydrogeologic investigations.

In the southern part of the Western Siberian Lowland there is a regular change in the chemical composition and mineralization of the ground waters, with increasing depth. Three hydrogeochemical zones have been distinguished, according to the degree of mineralization. The depths at which these zones occur along the Bol'sherech'ye—Omsk—Tatarsk profile are shown in Fig. 3. Table 3 shows the data on the mineralization of the ground waters, as derived from the results of measurements in the Bol'sherech'ye, Sargatka, Omsk and Tatarsk wells. The profile in Fig. 3 shows the connection between the geoisotherms and the hydrogeochemical zones. The top of the first hydrochemical zone, of methane calcium-chloride waters with mineral content more than 20 g/l in the Bol'sherech'ye well, occurs at the depth of about 2000 m. Toward Omsk it rises to 1600 m, and then descends again to the depth of 2600 m. In the Tatarsk well one observes a similar behavior of the top of the second hydrochemical zone, composed of methane calcium-chloride waters with mineral content from 20 g/l to 10 g/l. The third hydrochemical zone, with mineral content less than 10 g/l, contains ground waters whose chemical composition places them in the sodium-hydrocarbonate type.

Thus the areas of high temperatures correspond to areas in which the first and second hydrochemical zones occur closer to the earth's surface, whereas the lower temperatures in the vicinity of Tatarsk, on the other hand, correspond to an area in which the hydrochemical zones occur at greater depth. This ground water distribution is consistent with the concept of an inflow of cold and slightly mineralized waters from the folded margin on the south of the Western Siberian Lowland. The comparatively greater magnitude of the geothermal interval, and the occurrence of the hydrochemical zones closer to the surface at Omsk as compared to Tatarsk, apparently indicates a sharp wedging of the rocks south of Omsk or a tectonic dislocation in the Mesozoic rocks, which prevents the penetration of ground waters from the Kazakh crystalline massif.

It is of great practical importance to determine the movements of ground waters. The correct solution of this problem will considerably facilitate geologic prospecting for oil and gas. The existence of a zone of ground-water penetration at depth in the area of Tatarsk decreases the oil and gas prospects of this territory. Accordingly the Tatarsk, Krasnov and Ust'-Tark uplifts discovered here must be considered as low-prospect areas.

The general regional movement of ground waters from the south to the north and northwest indicates a migration of oil and dissolved gas in the same direction. Therefore the area of deeper occurrence of the Mesozoic deposits on the right bank of the Irtysh River, between the Om' and Tara Rivers, may be considered as a possible oil and gas collecting area from which the oil and gas may migrate northward and westward, under the influence of the movement of ground water and other factors, into an area of higher occurrence of these rocks. The Bol'sherech'ye, Novo-Loginov, Lozhnikov,

TABLE 3

Stratum number	Interval	Mineral content g/1	Water type
		BOL'SHERECH'YE TEST WELL 1-R	
I	2 646–2 670	—	
II	2 603–2 596	25.7	Calcium chloride
III	2 242–2 238	20.0	" "
IV—VI	1 939–1 932		
	1 912–1 906	19.1	" "
V	1 373–1 365	15.6	" "
VII	1 241–1 236		
	1 050–1 046	14.5	" "
VIII	582–577	9.4	Sodium hydrocarbonate
		OMSK TEST WELL 1-R	
I	3 001–2 830	21.0	Calcium chloride
II	2 766–2 761	30.49	" "
III	2 731–2 724	31.04	" "
IV	2 708–2 700	29.59	" "
V	2 650–2 640	28.87	" "
VI	2 525–2 518	29.02	" "
VII	2 430–2 425	27.03	" "
VIII	2 114–2 102	24.06	" "
IX	1 882–1 878	21.68	" "
X	1 827–1 821	23.75	" "
XI	1 735–1 720	23.68	" "
XII	1 389–1 384	9.68	" "
XIII	959–952	6.68	Sodium hydrocarbonate
		SARGATKA TEST WELL 1-R	
I	2 813–2 659.9	—	Calcium chloride
II	2 625–2 617	25.5	" "
III	2 595–2 588	24.5	" "
IV	2 510–2 493	23.8	" "
V	2 234–2 227	23.06	" "
VI	1 610–1 600	—	—
VII	1 572–1 557	14.6	Calcium chloride
VIII	1 143–1 139	14.7	" "
		TATARSK TEST WELL 1-R	
I	2 913–2 795	—	—
II	2 780–2 772	24.12	Calcium chloride
III	2 767–2 756	26.57	" "
IV	2 750–2 746	—	—
V	2 571–2 563	19.8	Calcium chloride
VI	2 468–2 462	—	—
VII	1 964–1 958	16.27	Calcium chloride
VIII	1 857–1 851	10.85	Sodium hydrocarbonate

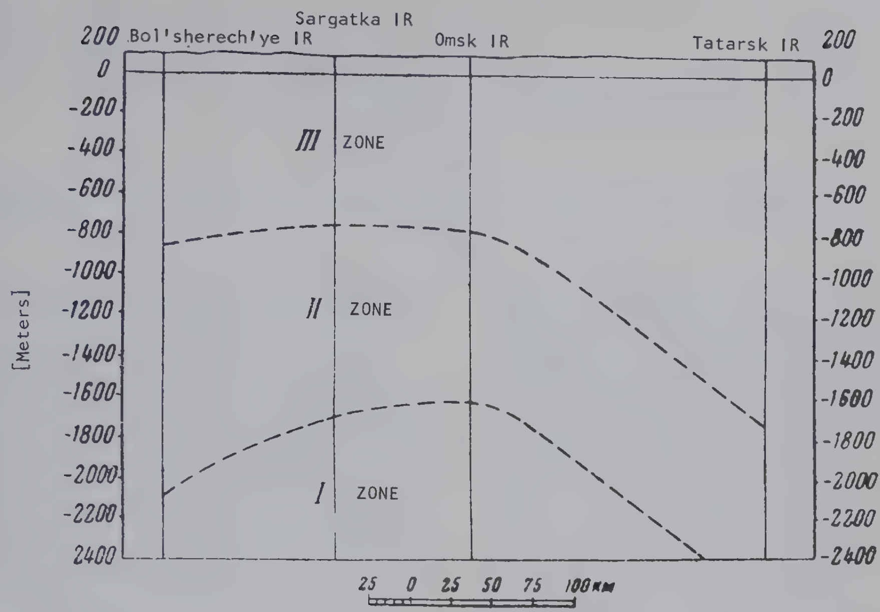

FIGURE 3. Hydrogeochemical section along the Bol'sherech'ye — Sargatka — Omsk — Tatarsk line.

Bazhenov and other uplifts discovered here show greater prospects for oil and gas occurrence than those in the areas farther south.

On the basis of the geothermal observations made in the south-central part of the Western Siberian Lowland, we may draw the following basic conclusions.

1. Geotectonically, the south-central part of the Western Siberian Lowland occupies a position intermediate between the eastern region of the Russian platform, with its Precambrian basement, and the areas of young Alpine folding in the Caucasus. The average magnitude of the geothermal interval in the southern part of the Lowland is 41.6 m, approximately twice that in the Caucasus and two times less than that on the Russian platform. The average magnitude of the geothermal interval in Dagestan is 21.4 m, in the Apsheron Peninsula 27.4 m, and in the Maykop area it is 25.1 m. In Bashkiriya and in the Belorussian Poles'ye (forest zone) it is, respectively, 82.6 m and 86.5 m.

2. The ground-water regime can be judged from geothermal observations. Rocks with a stable water regime are characterized by similar geothermal conditions at equal depths — that is, in such areas the magnitude of the geothermal interval is normal and is not related to the hypsometric position of the aquifer.

In the case of rocks with a dynamic ground-water regime, the geothermal interval increases, relative to its average magnitude, in the structurally less elevated parts and decreases in the structurally higher parts, if the waters enter the zones of uplift from zones of subsidence.

The evidence for the movement of the ground waters is the change in the geothermal interval. A decrease in the magnitude of the interval indicates movement of the waters in that direction. This means that as the cold waters descend from their source, they are heated in cooling the surrounding rocks and thus increase the geothermal interval relative to its average magnitude in the given region. In their farther downward movement the waters are heated still more, and as they encounter uplifted areas on their path and move upward with the elevation of the rocks, they release part of the heat which they have acquired at depth, accordingly increasing the magnitude of the geothermal interval.

These results of geothermal investigations in the south-central part of the Western Siberian Lowland support the conclusion that there is a connection between the geothermal and hydrogeological regimes; such conclusions have been drawn in papers by M. F. Belyakov [1], by G. M. Sukharev on the Terek-Dagestan region [3], and by V. M. Nikolayev on the Makhach-Kala oil deposit [2].

REFERENCES

1. Belyakov, M. F., Geotermicheskiye nablyudeniya v burovykh skvazhinakh i ikh interpretatsiya [GEOTHERMAL OBSERVATIONS IN DRILL HOLES AND THEIR INTERPRETATION]: Gostoptekhizdat, 1955.

2. Nikolayev, V. M., Geotermicheskiye usloviya v plastakh Makhachkalinskogo neftyanovo mestorozhdeniya [GEOTHERMAL CONDITIONS IN THE STRATA OF THE

MAKHACH KALA OIL DEPOSIT]: Neftyanoye Khozyaystvo, No. 6, 1949.

3. Sukharev, G. M., Geotermicheskiye osobennosti Tersko-Dagestanskoy neftegazonosnoy provintsii [GEOTHERMAL PROPERTIES OF THE TEREK-DAGESTAN OIL AND GAS PROVINCE]: Gostoptekhizdat, 1948.

FROM THE HISTORY OF THE GEOLOGICAL SCIENCES ANNIVERSARIES FROM JULY TO DECEMBER 1959[1]

by

V.V. Tikhomirov and T.A. Sofiano [2]

REVIEWER'S NOTE

Should be of wide reader interest. Information of this kind especially valuable to American readers, most of whom are not familiar with European geologists and their work.

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THE 250TH ANNIVERSARY OF THE BIRTH OF I.G. GMELIN

Iogan Georg Gmelin, the famous traveler, botanist and acting member of the Academy of Sciences in St. Petersburg, was born on August 12, 1709. As a result of his ten years of explorations and expeditions, he collected valuable information on the botany, geology and geography of the basins of the Lena, Yenisey, and Angara Rivers in the Transbaykal, and also in the Urals. (More detailed information on the geologic work of I.G. Gmelin will be found in the Izvestiya Akademii Nauk S.S.S.R., Ser. Geol., 1955, no. 2, 1. 130.)

THE 200TH ANNIVERSARY OF THE BIRTH OF G.K. RAZUMOVSKIY

Grigoriy Kirillovich Razumovskiy was born on November 21 (10), 1759. He studied at Leyden and Stockholm, where he pursued a course in philosophy and natural history, giving particular attention to mineralogy and geology. Then he moved to Lausanne, (Switzerland), where he founded a physical society whose members also concerned themselves with the study of geology. G.K. Razumovskiy devoted great efforts to the activity of this society, presented papers at its meetings, saw to the systematic publishing of its transactions and printed many of his own works on its publications.

In 1783 he published his first geologic work, "A Mineralogical Journey from Brussels to Lausanne", and a year later published another book on his geologic researches in various parts of Switzerland.

G.K. Razumovskiy was interested in a broad array of problems. He wrote described minerals, rocks, and mineral waters, carried out chemical investigations of natural compounds, and made experiments in the synthetic production of minerals. In his work G.K. Razumovskiy touched on problems of weathering, in regard to which he believed that minerals and rocks could not be disintegrated by the action of wind alone, but also required water and fire; he was interested in the origin of granite; and devoted great effort to the processes of transformation of some minerals and rocks into others by means of chemical replacement. Some of the papers of G.K. Razumovskiy were devoted to the description of fossil animals (polyps, trilobites, vertebrates and others) and plants. He identified several types of petrified wood, from almost unaltered to highly mineralized varieties. Some of his works involved problems of paleogeography; in particular, in analyzing the nature of sediments and the fauna contained in them, he concluded that between the Bodensee and the Danube River, the territory of Swabia and Bavaria was formerly covered by a fresh-water lake.

G.K. Razumovskiy's paper on the erratic boulders spread over northern Europe is of considerable interest. He was able to establish their regular distribution and to show that these boulders were deposited in two stages, each stage characterized by a different direction of movement.

In his works G.K. Razumovskiy devoted some attention to economic minerals. He studied the Olenets iron ores, dividing them into two types, and described the deposits of rock salt in Bavaria. He proposed a classification of fossil coals. Moreover G.K. Razumovskiy took a decisive stand on the then controversial problem of the organic origin of coal, believing, however, that some coal was formed from animal remains.

He was a member of several academies of sciences (at St. Petersburg, Stockholm, Turin and Munich), and was also an active member of a large number of scientific societies in Russia and other countries. The name of G.K. Razumovskiy was given to one of the minerals discovered by him — razumovskite (D.F. John, 1814). He died on June 3 (May 22), 1837, in Rudolets, Austria.

THE 175TH ANNIVERSARY OF THE BIRTH OF YA.G. ZEMBNITSKIY

Yakim Grigor'yevich Zembnitskiy was born in 1784. In 1807 he finished his studies at the

[1]Translated from Sovetskaya Geologiya, 1960, no. 1, p. 140-146, Review 25.

[2]Institute of Geology of the Academy of Sciences of the U.S.S.R.

Glavnyy Pedagogicheskiy Institut in St. Petersburg, and thereafter began his many years of teaching in the institutions of higher learning in St. Petersburg, where he taught zoology and botany. Beginning in 1814, for more than 30 years he gave lectures at the Gornyy Kadetskiy Korpus — leter called the Institute of Mining Engineers. Here he presented the first course in paleontology. Making extensive use of the materials in foreign literature, Ya. G. Zembnitskiy wrote the first manual on paleozoology in the Russian language ("A Conchology or Presentation of Information on Shellfish and Shell-Bearing Animals", 1831) and paleobotany ("A Brief Guide to the Systematic Identification of Fossil Plants Encountered in Various Layers of the Earth", 1833).

These were not merely textbooks, but treatises on the identification of fossil organisms. Because at that time there was virtually no Russian literature in paleontology, many of the terms proposed by Ya. G. Zembnitskiy have become part of Russian scientific terminology.

Ya. G. Zembnitskiy's books were of great value in the development of theoretical geology. He stressed, for example, that the external appearance of the shellfish is a basis for a reliable judgment of the paleoecology, and that from paleobotany one can determine the climatic conditions of the ancient world. Of great importance at that time was Ya. G. Zembnitskiy's statement of the need to study extinct forms in comparison with living plants and animals. These ideas ran against the then ruling ideas of the "catastrophists", who believed that in each new epoch, as a result of a succession of creative acts, there appeared new beings which had no connection with the formerly living organisms. Ya. G. Zembnitskiy was an adherent of the theory of gradual development of the organic world, from simple forms to more complex ones.

His writings and translations promoted the spread and development in Russia of the then new sciences of paleontology and biostratigraphy. He was one of the founders of the St. Petersburg Mineralogical Society, established in 1817. He took an active part in the work of this society, presented a number of his collections to it, and from 1827 to 1842 served as its director. Ye. G. Zembnitskiy died on November 18 (6), 1851.

THE 150TH ANNIVERSARY OF THE BIRTH OF THE SWISS PALEOBOTANIST O. HEER

Oswald Heer was born on August 31, 1809 in Switzerland. In 1831 he was graduated from the University at Halle, and in 1834 he began to teach botany and entomology at the University of Zurich, where he was appointed professor in 1852.

Heer's chief works were devoted to fossil plants. He described, in all their complexity, 1,947 new species and illustrated them in 764 plates. His first investigations of fossils were made in the period 1847-1849 in Switzerland and Croatia. During 1855-1859 he published a three-volume work on the Tertiary flora of Switzerland. In it he described a large number of new species of fossil plants and compared this flora with the Tertiary plants of other parts of Europe, and also with modern species.

In 1864 Heer published a popular scientific work, "Die Urwelt der Schweiz", in which he generalized the available information on paleobotany and paleontology of Switzerland. Here he presented illustrations of many of the fossil plants reconstructed by him.

Heer maintained close scientific contacts with Russian researchers, and received collections of specimens from them. From F. B. Shmidt in particular, he received remains of Jurassic plants from the Amur River basin. The results of his study of the materials on Siberia were published over the period 1869-1884 in O. Heer's seven-volume work on "Flora Arctica". The great scientific importance of this work lay in its systematization of the fossil plants of the northern hemisphere, and its analyses of the paleoclimatic conditions of different periods. Nevertheless the conclusions in this work were erroneous: in the problem of the development of organisms Heer was a proponent of "catastrophism", attributing the appearance of new and improved forms to successive acts of special creation.

He was also interested in problems of glaciation and concluded that in the Alps glaciation was repeated and was the result of a combination of terrestrial and cosmic factors. O. Heer died in Lausanne on September 27, 1883.

THE 125TH ANNIVERSARY OF THE BIRTH OF N. A. GOLOVKINSKIY

Nikolay Alekseyevich Golovkinskiy was born on November 29 (17), 1834 in Kazan. In 1861 he finished his studies in the Faculty of Physics and Mathematics at the University of Kazan, spent two years of specialized study abroad and, after returning to Kazan in 1864, he taught geology and paleontology at the University. N. A. Golovkinskiy was appointed professor in 1868. In 1871 he began to teach at the University of Novorossiysk (Odessa), where he later (from 1877 to 1881) served as Rector.

From his investigations in the Povolzh'ye region, N. A. Golovkinskiy discovered a number of the processes of sedimentation and relief formation characteristic of this region. He elaborated methods of detailed stratum-by-stratum study and correlation of section, and

showed the relationship between formation of beds and movements of shorelines.

N. A. Golovkinskiy was the first to present a clear conception of the oscillatory movements of the earth's crust and suggested the method by which they were fixed in sedimentary rock sections. He formulated the concept of the "geologic" datum plane, and showed the chronological displacement of the petrographic plane, that is, its lack of correspondence with the stratigraphic datum plane across its trend. He was the first to use the concept of "facies" in Russian geologic literature, and studied the reasons for the displacement of facies in time and space. The laws which he discovered regarding the displacement of various facies were first presented in his work "The Permian Formations in the Central Part of the Kama-Volga Basin" (1868), a concept which some twenty five years later was rediscovered by J. Walter and thus received the name of this German scientist.

In studying Quaternary deposits, N. A. Golovkinskiy showed the connection between river terraces and modern geomorphological relief forms and the vertical movements of the earth's crust. He determined that oscillatory movements are of different orders, and noted the lack of correspondence between the directions of the simultaneous tectonic movements in different places. His formulation of the causes of valley formation lies at the basis of modern geomorphological concepts. N. A. Golovkinskiy was also interested in problems of hydrogeology; in particular, he set forth some original ideas on the origin and regime of groundwater in the Crimea.

N. A. Golovkinskiy was a materialist, and held to the view of spiral development, from the simple to the complex. Being a progressive scientist, as a sign of his protest against the reactionary laws on education, he resigned first from Kazan and then from Odessa Universities. N. A. Golovkinskiy died on June 21 (9), 1897 in the Crimea.

THE 75TH ANNIVERSARY OF THE BIRTH OF V. S. DOKTUROVSKIY

Vladimir Semenovich Dokturovskiy was born on November 6, 1884 at Nikolayev. In 1907 he finished his studies in the department of natural sciences of the Faculty of Physics and Mathematics of the University of Moscow. In 1908 he moved to St. Petersburg and joined the Ministry of Agriculture, where he first worked in the transplanting administration, and then from 1912 to 1925 managed the botanical section. From 1922 to 1930 he headed the department of botany of the Peat Institute. In 1918 V. S. Dokturovskiy received the rank of Professor; he taught in the Surveying and Veterinary Institutes in the Mining Academy, and read lectures on paleobotany in the State University of Belorussia.

V. S. Dokturovskiy traveled widely; beginning in 1908, for a number of years he visited the Soviet Far East, carrying out investigations in the Amur region. Here, along with his study of the modern flora, he collected and described Jurassic plants along the Tyrma River. His paper was the first step in the study of the Bureya coal basin.

V. S. Dokturovskiy devoted much of his efforts to a study of the swamps and the Quaternary vegetation of European Russia. He believed that one could determine the relationship between the vegetative cover, the water regime and the geologic structure of a swamp, as well as the chemical composition of the peat, if one considered the swamp to be the result of a complex dynamic process. V. S. Dokturovskiy produced the first manual on swamps; through his initiative this branch of science was established as a separate course in the program of higher studies.

He was the first to apply pollen analysis to the study of the Quaternary flora. He was especially successful in using pollen diagrams to characterize the physical geography of the Riss-Würm interglacial stage. For his work in the study of swamps, V. S. Dokturovskiy in 1924 was awarded the Gold Medal of the Russian Geographical Society. V. S. Dokturovskiy died on March 20, 1935.

THE 75TH ANNIVERSARY OF THE DEATH OF V. G. YEROFEYEV

Vasiliy Gavrilovich Yerofeyev was born in 1822. In 1842 he finished his studies in the Institute of Mining Engineers and began to work there as instructor in paleontology and assistant curator of the museum. Thereafter he went for several years to France, where he engaged in specialized studies under E. Verneuil, A. D. d'Orbigny and L. Elie de Beaumont. Upon his return in 1855 he again took up his instruction in paleontology in the same Institute. In 1873 V. G. Yerofeyev was appointed Professor. In 1881 he was appointed Director of the Mining Institute, and a year later also became Director of the Geologic Commission.

V. G. Yerofeyev's main studies were in the field of paleontology and stratigraphy. Among his early works, "Fossil Tables for the Sedimentary Systems of Russia", published in the Russian translation of "The Geology of Russia" by Murchison, Verneuil and Keiserling (1849), is worthy of mention. These tables were based on an enormous amount of data and were for many years an important part of the scientific equipment of geologists working in Russia.

V. G. Yerofeyev made a systematic study of the paleontological collections in the museum of the Mining Institute. His identifications helped

greatly to clarify the stratigraphy of various regions of the country. Among his stratigraphic studies based on materials collected by himself, the most important were his work on the Devonian of the Andom Mountains and the Cretaceous deposits in the vicinity of Novgorod-Severskiy. His studies of the coal-bearing deposits of the former Turkestan region showed that E. I. Eichwald was in error in assigning these to the Carboniferous, and proved that these formations were of Jurassic age.

Among the major regional geologic investigations made by V. G. Yerofeyev was his work in the basin of the Upper and Middle Volga River. He also studied economic minerals; his discovery of industrial deposits of rock salt in the vicinity of Bakhmut was of great importance. V. G. Yerofeyev was the author of a text on paleontology, which in his time was universally celebrated. He was a member of a number of Russian and foreign scientific societies. V. G. Yerofeyev died on December 29 (17), 1884.

THE 50TH ANNIVERSARY OF THE DEATH OF THE HUNGARIAN GEOLOGIST JANOS BOECK VON NAGYSUR

Janos Boeck von Nagysur was born on October 26, 1840 in Samoria, in the Bratislava district. He was graduated from the Mining Academy in 1862, and thereafter specialized in geology under E. Suess at the University of Vienna. In 1867 Jan Boeck was sent to Budapest to serve as geologist in the Ministry of Finance, and in 1882 began work in the Department of Geology of the University of Budapest. Jan Boeck's first major work was his geologic description of the Bukovina, based on his own investigations.

In the period from 1873 to 1879 he studied the stratigraphy of the Triassic and Liassic of the Bakon forest. Among his best known works is his investigation of the geology of the Banat (1877). Jan Boeck devoted particular attention to geologic mapping. He was the author of a detailed geologic map of Old Hungary, and also of the widely known and larger geologic map of Hungary, published in 1896 together with a survey of the history of researches in this territory over a period of more than a century.

In 1898, together with Alexander Hessel, he produced a general map of the economic minerals of Hungary. For a number of years he worked in the oil regions of Hungary, studying the results of the drilling done there. In 1909 he presented a summary report with his conclusions regarding the oil content of the region and the conditions of occurrence of economic minerals within it.

For his great achievements in the field of geology he was elected a Corresponding Member of the Hungarian Academy of Sciences. In 1907 he was given noble rank and was awarded the additional name of von Nagysur. Janos Boeck von Nagysur died on May 10, 1909 in Budapest.

THE 50TH ANNIVERSARY OF THE DEATH OF A. E. GEDROYTS

Anton Edmundovich Gedroyts was born in the Vilno uyezd in Lithuania (then part of the Russian Empire). He was graduated from the Yekaterinoslav Mining College and worked for many years in Lithuania, Belorussia and adjacent areas of Poland.

In 1895 his summarizing work on the geology of this extensive region was published. From 1883 he was a staff member of the Geological Commission and worked in a large number of far-off areas of the country. As a member of the Transbaykal Mining Expedition he produced petrographic descriptions of the granites, tonalites, porphyries and other igneous rocks of Eastern Siberia. He investigated the basin of the Shilka River, concentrating his attention on the plutonic and metamorphic rocks, the gold-ore placers and various ore occurrences; silver-lead, mercury, iron, manganese and graphite.

A. E. Gedroyts also studied the carbonic acid mineral spring in the Kakhtalga River valley. Gedroyts's paper on the problem of the Uzboy is of great interest; in studying the rivers of Central Asia, he came to the conclusion that the Uzboy is the ancient channel of the Amu-Dar'ya River, which formerly flowed into the Caspian Sea.

While on an expedition, A. E. Gedroyts took sick and was compelled to return to his country. He died at Vilna on November 8 (October 26), 1909.

THE 50TH ANNIVERSARY OF THE DEATH OF S. N. NIKITIN

Sergey Nikolayevich Nikitin was born on February 4 (January 23), 1851. In 1871 he finished his studies in the department of natural sciences of the Faculty of Physics and Mathematics of the University of Moscow. In 1875 he began to teach geology and mineralogy at the Courses of Higher Education for Women in Moscow. From the very beginning of the existence of the Geological Commission S. N. Nikitin took an active part in its activities, serving as senior geologist.

S. N. Nikitin was a scientist of varied interests. His major investigations in paleontology, paleogeography, stratigraphy, hydrogeology, hydrology, physical geography, regional and applied geology, are well known.

The most important of S. N. Nikitin's works were devoted to problems of stratigraphy. He studied the coal measures of the Moscow basin, the Permian formations in the Cis-urals and the Mesozoic sediments of the Russian platform. His correlation of the Jurassic deposits of Russia and Western Europe is of great scientific interest.

In the field of paleontology, S. N. Nikitin held to the theory of evolution as developed by Charles Darwin. The phylogenetic relationships which he developed between certain groups of Callovian and Oxfordian ammonites are indicative in this regard.

In his examination of the problem of Quaternary glaciation, S. N. Nikitin established the limit of distribution of the glacial formations and came to the conclusion that the relief of the Russian Plain is very ancient.

S. N. Nikitin composed the first reports on the hydrogeology of European Russia, noting the direct connection between ground water basins and the geologic structure of the territory, and thus established the existence of large reserves of ground waters in the Moscow Basin.

Of great practical and scientific significance was S. N. Nikitin's "Bibliography of the Literature on the Water Wells Drilled in Russia" (1911), which went through two editions. S. N. Nikitin attributed great importance to bibliography, and for fourteen years issued an annual bibliography, "The Russian Geological Library". S. N. Nikitin died during the night of November 17-18 (4-5), 1909.

THE 50TH ANNIVERSARY OF THE DEATH OF I. A. LOPATIN

Innokentiy Aleksandrovich Lopatin was born in 1838 at Krasnoyarsk. In 1860 he finished his studies at the Institute of Mining Engineers and was sent to the Nerchinsk mining area. He worked in Eastern Siberia and in the Russian Far East. His observations resulted in a great amount of factual data on the geology and geography of this territory. In the region of Lake Baykal, he studied seismic phenomena, and was particularly interested in the aftereffects of earthquakes at the mouth of the Selenga River; in the Ussuriyskiy area and the Vitim flatland he investigated the gold placers, establishing their distribution and genesis. Together with F. B. Shmidt, in 1866 he investigated the basin of the Yenisey River, settling at Noril'sk and becoming familiar with the deposits of copper ores, coal and graphite.

In studying Southern Sakhalin in 1867-1868, I. A. Lopatin worked out its tectonics and showed the industrial importance of the coal deposits of this area.

In the course of his work, along with his study of economic minerals, he paid great attention to stratigraphic problems. He established the presence of Silurian deposits along the Podkamennaya Tunguska River and of Devonian sediments (with fish fauna) in the Minusinsk area; on the Chuly River he discovered a Miocene flora.

The data collected by I. A. Lopatin on the traces of ancient glaciation discovered by him in various regions of Siberia, are of great interest.

I. A. Lopatin made several journeys at the behest of the Russian Geographic Society and the Academy of Sciences. The extensive collections made by him are of considerable scientific value and are preserved in the appropriate museums. I. A. Lopatin's works in print were few in number, but his diaries, travel notes and collections have been worked over, studied and described by a number of important scientists, so that his observations and investigations have played quite a large role in increasing the knowledge of a whole series of little-studied regions of Siberia. A mountain on the island of Sakhalin was named after I. A. Lopatin. He died on November 28 (15), 1909.

THE 10TH ANNIVERSARY OF THE DEATH OF I. V. PALIBIN

Ivan Vladimirovich Palibin was born in Tiflis on April 9 (March 28), 1872, into a soldier's family. After following the course of instruction in the Corps of Cadets, in 1889 he began to work first in the Moscow and then in the St. Petersburg botanical gardens, where he specialized in the field of botany. Wishing to extend his scientific knowledge, in 1906 he entered the University of Geneva and studied there until 1910.

From 1932 I. V. Palibin was chief of the newly created section of paleobotany in the Botanica Institute, and put much effort into the development of research there. He organized the paleobotanical section in the All-Union Institute of Oil Prospecting. In 1934 I. V. Palibin was granted the degree of Doctor of Biological Sciences, and in 1939 appointed to the rank of Professor; in 1946 he was awarded the honor of Meritorious Worker in Science.

I. V. Palibin began his paleobotanical investigations in 1901 with the voyage of the icebreaker "Yermak" to the Polar Islands (Franz Josef Land, Spitzbergen, and the Northern Island of Novaya Zemlya). He was sent to Sweden, Denmark and Norway to put in order the collections of specimens made by him. Thereafter he worked in the Povolzh'ye region and in the Caucasus. From 1916 to 1923 I. V.

Palibin directed the botanical garden at Batumy; he also made an expedition to Asia Minor, where in particular he made a collection of Carboniferous flora. In addition to the Caucasus, he was interested in Siberia and the Russian Far East. I. V. Palibin devoted his paleobotanical papers mainly to Tertiary flora. He studied the Paleocene flora of the Povolzy'ye and the Tertiary flora of Sikhote-Alin', Kazakhstan and Burey. He also described the Mesozoic flora of some districts of the Transcaucasus, as well as the remains of Quaternary plants in the vicinity of Mt. Mashuk. I. V. Palibin's work, in which he presented a picture of the development of vegetation in the Caspian region from the Cretaceous to the Recent times, is of great scientific importance. He established that O. Heer was in error in identifying the age of the vegetation in the Burey Basin as Miocene; according to his conclusions it was older. I. V. Palibin's name has been given to a large number of modern and fossil plants. I. V. Palibin was a member of many Soviet and foreign scientific societies. He died on September 30, 1949.

THE 10TH ANNIVERSARY OF THE DEATH OF V. I. LUCHITSKIY

Vladimir Ivanovich Luchitskiy was born on May 2, (April 20), 1877, in Kiev. In 1899 he finished his studies in the department of natural sciences of the Faculty of Physics and Mathematics of the University of Kiev, and was appointed in the department of mineralogy to prepare for the rank of Professor. Then for two years he studied abroad, under the most distinguished Western European mineralogists and petrographers of the time. Upon returning to Kiev, he lectured on petrography in the University and in the Higher Courses for Women. In 1907 V. I. Luchitskiy defended his master's dissertation and in the same year was chosen Prorector and Director of the Department of Mineralogy and Petrography of the Warsaw Polytechnical Institute. In 1912 he received the degree of Doctor of Mineralogy and Geognosy, and in 1914 was appointed Professor of Geology and Paleontology at the University of Kiev. In 1917 V. I. Luchitskiy organized the Ukrainian Geological Commission in Kiev, and headed it for six years. Thereafter he worked in the Moscow Mining Academy and in the Moscow Institute of Geological Exploration. From 1935 on V. I. Luchitskiy was a member of the Institute of Geological Sciences of the Academy of Sciences of the U. S. S. R. In 1945 he was elected acting member of the Academy of Sciences of the Ukrainian S. S. R., and in 1947 became director of the Institute of Geology of the Academy of Sciences of the Ukrainian S. S. R.

V. I. Luchitskiy is widely known for his works on petrography and regional geology. Even in the early years of his scientific career, he devoted a number of papers to the microscopic structure of the Paleogene sandstones. In the period from 1903 to 1912 he studied the Jurassic slates of the Crimea, paying special attention to contact alterations caused by the adjacent igneous rocks; he investigated the crystalline massif of the Ukraine and the rocks of the Tarbagatay Range (Eastern Kazakhstan). He produced a great work on regional geology in the area encompassed by the 31st sheet of the general geologic map of Russia, instituted major investigations of the hydrogeology of the Ukraine, and prepared the first summary of radioactive minerals in Russia (1915).

In his position as director of the Ukrainian Geological Commission after 1917, he prepared and published summary maps of the Ukraine (geology, hydrogeology and economic minerals). A considerable part of V. I. Luchitskiy's work was devoted to the study of mineral raw materials. He investigated the phosphorite-bearing deposits of the Kiev region, the graphite and kaolin deposits of the Ukraine, deposits of sulfur and iron ores in the Kerch Peninsula, salt and lead in the Crimea, chromites in the Urals, corundum in Kirghizia, etc. In the very earliest stage of exploration for oil, V. I. Luchitskiy published an article on the salt domes and the oil content of the Romnyy region.

V. I. Luchitskiy wrote many papers on Precambrian rocks. He made a microscopic study of the crystalline rocks of these systems and suggested a stratigraphic scheme for the Archean and Proterozoic rocks of the Ukraine. His investigations promoted the knowledge of the metallogeny of the crystalline zone, and were successfully used in field studies of rare and dispersed elements. He published a monograph on the Precambrian formations of the European part of the U. S. S. R.

V. I. Luchitskiy was the author of a number of scientific textbooks: "Petrography", "Petrographic Provinces of the U. S. S. R." and "Petrography of the Ukraine". He died on October 20, 1949.

THE 10TH ANNIVERSARY OF THE DEATH OF N. G. KASSIN

Nikolay Grigor'yevich Kassin was born on December 13 (1), 1885, in the vicinity of Vyatka, into a peasant family. In 1905 he entered the St. Petersburg Mining Institute. An active participant in the revolutionary movement, he was Secretary of the Social-Democratic Student group. In 1907 he was arrested and exiled; thus N. G. Kassin did not finish his education until 1913. From 1917 he worked in the Geological Commission, and thereafter in TSNIGRI and VSEGEI.

N. G. Kassin began his practical work under the direction of such great geologists as K. I.

Bogdanovich, D. V. Golubyatnikov and P. I. Stepanov, mainly in the various regions of Kazakhstan.

In 1912 - 1913 he produced the first ten-verst map of the earlier unstudied region of Turgay and Irgyz. On the basis of his paleontological investigations, he worked out the stratigraphy of the Tertiary deposits of this territory.

In the period from 1914 to 1916 N. G. Kassin directed the preparation of the ten-verst map of Southeastern Kazakhstan (the Issyk Kul' Basin, almost all of Central Tyan'-Shan' and the southern slopes of the Dzhungar Alatau Range). As a result of these investigations, he published, in addition to the maps, materials on the stratigraphy, lithology, tectonics, volcanic activity and petrography of the igneous rocks, economic minerals and ground waters of this extensive region.

From 1918 to 1924 N. G. Kassin was engaged in the preparation of a map of the Vyatka Guberniya. The new data obtained by him here were generalized in a monograph in which he proposed the first detailed subdivision of the Tatarian stage of the Upper Permian (into thirteen suites). For this work the Russian Geographical Society awarded him the Great Przheval'skiy Gold Medal.

From 1925 N. G Kassin was occupied for five years in the study of the geologic structure of Central Kazakhstan. His materials have become the basis for all further work in that area, and even at this time have not lost their scientific importance. He was the first to discover Ordovician and Silurian deposits there, and he significantly improved and clarified the stratigraphy of the Devonian and Lower Carboniferous. He was also the first to make a clear delimitation of the individual phases of the Caledonian and Hercynian tectonic movements and to produce a petrographic description of the igneous manifestations connected with these phases.

At the time of the organization of the Kazakh Geological Administration, N. G. Kassin was a consultant in almost all the investigations carried out under that system.

N. G. Kassin took an active part in the preparation of Volume XX of the "Geology of the U. S. S. R." (Eastern Kazakhstan), and served as its editor. This work generalized and brought together the previously disconnected extensive factual data, and determined some of the laws characterizing the distributions of areas of uplift and subsidence, as well as the association of various economic minerals with specific districts of Kazakhstan. In 1946 this work was awarded the Stalin Prize of the First Order. Another work by N. G. Kassin, "Materials on the Paleogeography of Kazakhstan", is of great scientific importance. For his great achievements in the study of the geology of Kazakhstan, N. G. Kassin in 1946 was elected Acting Member of the Academy of Sciences of the Kazakh S. S. R. N. G. Kassin died on October 28, 1949.

THE 10TH ANNIVERSARY OF THE DEATH OF M. E. YANISHEVSKIY

Mikhail Erastovich Yanishevskiy was born in 1871 at Kazan. He was graduated from the University of Kazah (in 1895) and was appointed to the department of Geology and Mineralogy. In 1902 he was appointed Professor in the Tomsk Technological Institute, where he worked until 1911. In 1911 M. E. Yanishevskiy was dismissed for his opposition to the government. From 1912 to 1932 he worked on the Geological Commission. In 1916 M. E. Yanishevskiy began to teach geology in the Petrograd Higher Courses for Women, and then moved to the University of Leningrad, where he remained for the rest of his life.

M. E. Yanishevskiy's main work was in paleontology and stratigraphy. He studied various groups of organisms among the coelenterates, worms, graptolites, brachiopods, mollucks, arthropods and verterbrates, belonging to all the systems of the Paleozoic. His work on the Lower Carboniferous brachipods, and also on the Cambrian deposits of the Russian platform, is especially famous. His investigations in the Povolzh'ye, Western Siberia and the Urals promoted the knowledge of their geologic structure and the study of their economic mineral deposits.

As a staff member of the Geological Commission, M. E. Yanishevskiy directed the work of the Quaternary Committee, and participated actively in the organization of the museum. In the last years of his life he was director of the Scientific Research Institute of the Earth's Crust at the University of Leningrad. For his many years of fruitful work he was awarded the distinction of Meritorious Worker in Science of the F. S. F. S. E. M. E. Yanishevskiy died on December 4, 1949.

COMPARATIVE CHARACTERISTICS OF THE TIN-BEARING GRANITOIDS OF DIFFERENT AGES OF THE SOUTH PRIMOR'YE AND CERTAIN OTHER TIN-BEARING AREAS[1]

by

Ya. D. Gotman and M.G. Rub

REVIEWERS NOTE

Very interesting paper that will have fairly wide reader appeal. Literature citations and references cited are rather poor and inadequate.

ABSTRACT

A comparison of the petrogeochemical characteristics of tin-bearing granites of different age of South Primorye, the Khabarovsk region, and other tin-ore areas, is given.

It is shown that in the regions studied tin is usually contained in the most highly acid, potassium-enriched differentiates of multi-phased intrusive complexes, in the formation of which hybridization processes played a considerable part. Data shows that the tin-bearing granites occurring in different structural facies zones as well as granites of different age developed in one and the same province show characteristic petrochemical peculiarities in addition to many other features they have in common. --Auth. English summ.

* * *

As is well known from numerous works of Soviet and foreign geologists, any number of significant tin deposits are associated with acid intrusive rocks of different age, among which Precambrian and lower Paleozoic granites are of subordinate significance. The intensive efforts of geologists to detect characteristic features of tin-bearing granites are thus understandable.

In 1912, Ferguson and Bates, comparing tin-bearing granites of different tin provinces, concluded that they are characterized by a wealth of alkalis and by the prevalence of potassium over sodium [16]. Westerfield [not in references] came to this same conclusion in 1936 when studying Malaya granites and comparing them with the granites of Cornwall, Rudnyy Mts., and Bolivia. Westerfield noted also that a higher content of rare metals is observed in tin-bearing granites.

Iv. F. Grigoryev [3], in studying tin-bearing granites of Zabaykalye, established that in comparison with normal biotitic granites, they are characterized by an increase of feldspar lime, an increase of alkalis, the presence of tourmaline and fluorite among the accessory minerals, and certain other properties.

One of the authors of the present article [2], generalizing the materials on tin-bearing granites of the Soviet Union and foreign countries, concluded that tin-bearing granites are usually characterized by an increase of silica, alumina, and alkali and by a decrease of calcium and magnesium oxides. He noted that tin-bearing granites in a series of tin-ore provinces are distinguished by an increased content of rare elements and are usually greisenized to some degree. S. D. Popov, having noted that the clarke of tin in tin-bearing granites surpasses considerably its clarke in the crust of the earth, came to similar conclusions.

A detailed geologic-petrographic and petrochemical study of tin-bearing granitoids of different ages of the Khankaysk-Daubikhinsk district showed that the granitoids of different age in this district possess some distinguishing properties together with features common to granites of other tin-bearing districts of the U. S. S. R. and other countries.

In the Khankaysk-Daubikhinsk district the upper Paleozoic granites of the second and third phase of the Grodekovsk intrusive complex and the Upper Cretaceous granites of the Maryanovsk intrusive complex are tin-bearing.

Characteristic of the tin-bearing granites of the Grodekovsk intrusive complex second phase are the following mineralogic, petrographic, and petrochemical properties:

1) Prevalence of potassic feldspar, usually microcline, over plagioclase.

2) Small amount of dark-colored minerals (to 4%) represented largely by biotite.

3) Quite broad development of albitization; secondary albite is developed both by plagioclases of the first generation and by potassic feldspars.

4) Development of quartz metasomatism,

[1]Sovetskaya Geologiya, 1960, no. 2, p. 48-56.

i. e., potassic feldspars and plagioclases are replaced by quartz.

5) Sharp supersaturation of rocks by alumina with small content of magnesium and calcium oxides.

6) Increased content of alkalis, mainly calcium oxide, especially in porphyritic biotitic granites of endomorphic facies.

7) Increased content of accessory boron and florine in biotites as well as the presence in them of tin and beryllium, occasionally rubidium also.

8) Increased content of barium and a small amount of lead, copper, gallium, rubidium, and tin in potassic feldspars.

9) Considerable zircon with a small amount of tourmaline, fluorite, and cassiterite (a chief property in the composition of accessory minerals).

10) Characteristic of the accessory elements are: barium, rubidium, beryllium, lithium, zirconium, yttrium, boron, fluorine, tin, gallium, and lead.

11) Development of greisenization.

Granites of the Grodekovsk intrusive complex third phase are very similar by their own petrographic composition and petrochemical properties to second phase granites (Grodekovsk proper). In particular, they are also characterized by a sharp supersaturation of silica, by a small quantity of calcium and magnesium oxides, by an increased content of alkalis, predominantly potassium over sodium, and by the presence, as accessories, of boron, fluorine, beryllium, and tin.

However, with this great similarity of petrochemical properties of Grodekovsk and Voznesensk granites a number of differences show up all the same. Voznesensk granite differs in the following properties:

1) Shape and dimensions of massifs. The Grodekovsk granites make up huge massifs, the Voznesensk granites make up relatively small massifs, the area of which does not exceed 15 to 20 km^2.

2) Structure. The Grodekovsk granites are usually large-grained, the Voznesensk granites are medium-grained, commonly porphyritic.

3) Strong development of albitization and quartz metasomatism. Increased amount of sodium is fixed in all areas and in later magmatogene formations, to which albitic veinlets, scapolitic and prehnitic scarns bear witness.

4) Markedly great amounts of tourmaline, fluorite, and cassiterite as accessory minerals.

A comparison of chemical analyses of the Grodekovsk and Voznesensk granites and of numerical characteristics obtained in an evaluation of the analysis according to the A. N. Zavaritskiy method also uncovers some differences in the composition of these granites with a large number of common features. The differences are the following: Voznesensk granites usually contain a larger amount of silica and potassium oxides and a smaller amount of calcium and magnesium oxides, thus, Q is always greater in Voznesensk granites; the parameter C of Voznesensk granites is usually less than unity, while in Grodekovsk granites this parameter varies between 1 and 2.

Characteristic of both Grodekovsk and Voznesensk granites as accessory materials are: boron, fluorine, beryllium, lithium, and tin, but in Voznesensk granites these elements are present in greater quantities. Processes of greisenization are developed both within the limits of Grodekovsk massif and of massifs complicated by Voznesensk granites, but greisenization processes are much more widely developed in massifs complicated by Voznesensk granites, typical greisens having wide development together with greisenized granites. Thus, a comparison of second and third phase granites of the upper Paleozoic intrusive complex permits the thought that the development process leads to gradual acidification and enrichment by volatile matter of an upper Paleozoic magmatic chamber, the role of calcium, magnesium and iron gradually decreasing, and the role of silicic acid and potassium increasing. Departures from this scheme, well-known in this studied district, are caused exclusively by the influence of the containing rocks. As the largest tin-bearing deposits in the studied district are genetically associated with the Voznesensk granites, the most acid later differentiates of the upper Paleozoic magmatic chamber enriched by potassium and volatile matter may be considered the most promising as to tin-bearing character.

It is interesting to note that the non-tin bearing granites of Russky Lake, of the Ryazanobka River basin, and of other regions of South Primorye do not contain cassiterite among the accessory minerals; fluorite and tourmaline are usually absent or there is very little of them. Tin is also absent in biotites taken away from these granites. Non-tin-bearing granites generally contain a lesser amount of accessory minerals and elements. Greisenization processes are not characteristic of them in the same way as of their exomorphic zones.

Upper Cretaceous tin-bearing granites of the Maryanovsk intrusive complex, developed in the Daubikhinsk syncline zone, also possesses

some distinguishing features in comparison with the upper Paleozoic tin-bearing granites of the Grodekovsk intrusive complex. A larger amount of microcline-perthite and more acid plagioclase, represented as albitite and albitite-oligoclase, is contained in the Maryanovsk granites. The process of replacement of potassic feldspar by quartz is developed more intensively in them. Zircon and orthite among the accessory minerals are characteristic of Maryanovsk granites; the latter is found very rarely and in small amounts in the granites of the Grodekovsk intrusive complex. Moreover, naegites [nagyagite?] and fergusonite completely absent in Grodekovsk granites, are found among the accessory minerals of Maryanovsk granites.

In chemical composition, the medium-grained and porphyritic biotitic granites of the Maryanovsk intrusive complex are closely related to the Voznesensk granites, differing somewhat from the latter in a greater amount of silicic acid and potassium oxide and in a smaller amount of magnesium and calcium oxides.

Among the accessory elements characteristic of Maryanovsk granites, apart from zirconium, are yttrium and tin, niobium and lanthanum, which are found in insignificant amounts or not at all (e. g., niobium) in Grodekovsk and Voznesensk granites.

Zirconium and yttrium are contained in markedly great amounts in Maryanovsk granites in comparison with Grodekovsk and Voznesensk granites, and the barium and strontium content is sharply decreased.

In contrast to Grodekovsk and Voznesensk granites there is much less lithium in Maryanovsk granites but in biotites of Maryanovsk granites there is more. There is usually no arsenic in Maryanovsk granites. The index of refraction of potassic feldspar in Maryanovsk granites is greater than in Grodekovsk granites; this is associated with the increase of barium content in the former.

Apart from the fact that biotites of Maryanovsk granites contain more lithium, they differ from biotites of the Grodekovsk intrusive complex in a higher titanium content and in a lower content of magnesium, water and barium. In contrast to Voznesensk granites where the greisenization processes are widely and intensively developed, they are weakly developed in the Maryanovsk granites. If on contact with the Voznesensk granites in the containing sedimentary rocks, tourmalinization, fluoritization and enrichment by cassiterites is observed, apart from quartzification, on contact with the Maryanovsk granite formation of various hornfels, chloritization, and only a very weak tourmalinization occurs.

Large massifs of Tertiary leucocratic and alaskitic granites are distributed on the eastern slope of Sikhote-Alin in districts of development of tin deposits. In chemical composition, they are related to the above granite rocks, but according to M. A. Favorsky [11] and F. K. Shipulin [12], they differ somewhat in a smaller content of silica and alkalis. The Tertiary granites of the eastern slope of Sikhote-Alin also differ by their own properties in composition of accessory minerals and elements. Thus, according to F. K. Shipulin, there is no cassiterite or very little cassiterite, tourmaline and fluorite, but garnet and molybelenite, not characteristic of granite of the Khankay-Daubikhinsk district, are present. In the Tertiary granites F. K. Shipulin notes the presence of such accessory elements as beryllium, zirconium, gallium and molybdenum, but M. A. Favorsky mentions barium also. At the same time there is no rubidium, boron, fluorine, lithium, tin, and lead, so characteristic of upper Paleozoic granites of the Grodekovsk intrusive complex.

Together with the large massifs of leucocratic and alaskitic granites, relatively small massifs of more basic rocks of different composition from granodiorites to gabbro and gabbro-norites are developed in districts of development of tin deposits of sulfide-cassiteritic formations on the eastern slope of Sikhote-Alin. The presence in them of quartz and potassic feldspar in association with basic plagioclases (andesite, labradorite and even bytownite), as well as monoclinic and rhombic pyroxenes, the glomeroplasmatic distribution in rocks of dark components, often well expressed monzonitic structure, the development of such accessory minerals, such as apatite and titanite, and finally the variability of composition of rocks within the limits of one outcropping – all these features reveal the hybrid character of these relatively more basic rocks.

It must be added that the described rocks are usually absent directly in areas of tin deposits of cassiterite-sulfide formation. The association of such deposits with intrusive rocks is established on the basis of the development in areas of deposits of numerous dikes of dioritic and diabasic porphyrites, which, for all their distinction from the above mentioned granitoid rocks of basic composition, carry the same features of hybridization.

In places, together with dikes of medium and basic composition of rocks, dikes of acid composition are developed, among which these are some later than dikes of porphyrites. Thus, hybrid rocks probably arise at some stage from one common chamber of acidic granite magma. Judging by the fact that the space connection of cassiterite-sulfide deposits with these more basic rocks is established in a number of sites (northeast Asia, some districts of eastern Zabaykalye, Bolivia), it may be supposed that the phenomena of assimilation of acid granite magma

at depth by rich iron and magnesium rocks (as a result of which hybrid rocks of more basic composition arise) caused also loss from the magma, together with tin, of a number of other elements forming cassiterite-sulfide ores.

Comparison of upper Paleozoic tin-bearing granites of the Prikhankaysk district with the Upper Cretaceous tin-bearing granites of the new tin-ore Myao-Chansk district (Khabarovsk Kray)[2] had shown that, they possess a number of petrochemical properties in common. Both the first and the second are more acid, and are derivatives enriched with potassium of complex multiphase intrusive complexes. Characteristic of the latter is the wide development of processes of hybridism occurring in the upper and lower structural stages. The leading accessory minerals of granitoids of the Myao-Chansk intrusive complex, together with zircon, apatite, tourmaline, and cassiterite, are also orthite, fergusonite, and molybdenite, not characteristic of the Grodekovsk intrusive complex granites. In addition, fluorite is absent in granitoids of the Myao-Chansk intrusive complex. The leading accessory elements of the Myao-Chansk intrusive complex granitoids, together with Rb, Li, Zr, B, Sn, Ga, and Pb, are also Cs, Mo, rare earths and Nb, not characteristic of granites of the Grodekovsk intrusive complex. Thus, the tin-bearing granitoids of the intrusive complex considered, having a number of common petrochemical features (wealth of potassium, tin, boron, lithium, rubidium), possess some properties distinguishing them from the upper Paleozoic granitoids of the Grodekovsk intrusive complex. To these properties are related:

1) The sharply subordinated role of fluorine and the considerably great role of boron. Fluorine in the Myao-Chansk intrusive complex granitoids and in the post-magmatic formations associated with them make use of very limited distribution, while in granites of the Grodekovsk intrusive complex it is the leading element. As we described earlier [8], quartz-topaz greisens are widely developed in the Prikhankaysk district being formed in granites and rocks and arenaceous-shale rocks and micaceous-fluoritic ores related with limestones. In this region, in connection with these granitoids, fluoritic-topaz rocks were formed at a later stage of post-magmatic processes under the actions of fluoride emissions due to quartz-topaz greisens and micaceous-fluoritic rocks. In the Myao-Chansk district in connection with Myao-Chansk intrusive complex granitoids a tourmaline mineralization was manifested. The magma from which these granitoids were formed was enriched by boron. Thus, among the granites of the third phase of the Myao-Chansk intrusive complex were distributed the tourmaline-containing granites, in which the formation of tourmaline had occurred at the end of the magmatic process itself. Further, formation of quartz-micaceous tourmaline greisens is associated with the earlier stages of post-magmatic processes; the formation of quartz-tourmaline and tourmaline rocks is associated with the later stages of post magmatic processes accompanying the Myao-chansk intrusive complex granitoids. Of interest is the fact that tourmalines of tourmaline-containing granites, quartz-micaceous-tourmaline greisens and tourmaline rocks possess in common a number of admixed elements. Thus, they invariably contain Li, Sr, Sn, Cu, Ga. However, the tourmalines of the tourmaline-bearing granites are characterized by certain properties; in particular, a larger quantity of potassium is noted in them, and of the admixture elements, apart from those mentioned above, Y and Sc have been established.

2) The sharply subordinated role of beryllium. Beryllium is very rare in the Myao-Chansk intrusive complex granitoids and always in amounts considerably lower than the clarke.

3) The invariable presence of cesium. Cesium is present in inconsiderable amount in all three phases of the Myao-Chansk intrusive complex, but reaches a maximum in high-temperature post-magmatic formations. Cesium is absent in low-temperature post-magmatic formations.

4) The presence, among accessory minerals of the third phase granites of the Myao-Chansk complex, of fergusonite which is absent in granites of the Grodekovsk intrusive complex.

Comparing in chemical composition the tin-bearing granites of southern Primorye with the tin-bearing granites of Kolyma, eastern Siberia, Altay, the Urals, and foreign countries (see table 1), it is evident that the tin-bearing granites of southern Primorye possess certain excellent properties. Thus, granites of the third phase of the upper Paleozoic intrusive complex (Voznesensk) and the Upper Cretaceous Maryanovsk granites are distinguished from the average type of tin-bearing granites by a still lower content of calcium and magnesium oxides and by a somewhat larger content of calcium oxide, as well as by the presence of boron, fluorine, and other accessory elements.

Further comparison of the tin-bearing granitoids of southern Primorye with granitoid rocks of other tin-bearing provinces (it is true the provinces are far from having been studied sufficiently) uncovers both features of similarity and features of difference present in tin-bearing rocks of each tin-ore province.

[2] Formation of these granitoids occur in the course of three subsequent phases related to one intrusive complex called by us the Myao-Chansk. The first phase of this complex is represented by hybrid rocks formed as a result of deep-seated assimilation.

TABLE 1

Oxides	Median Chemical Composition, %								
	I	II	III	IV	V	VI	VII	VIII	IX
SiO_2	70.88	73.2	75.29	75.15	76.36	72.18	74.43	71.22	73.12
TiO_2	0.26	0.14	0.11	0.07	Undeter.	0.3	0.14	0.27	0.18
Al_2O_3	15.14	14.3	13.30	12.98	13.20	13.7	13.02	14.79	14.03
Fe_2O_3	1.53	1.01	0.73	0.91	0.67	0.27	0.56	1.10	0.83
FeO	0.67	0.54	0.78	0.92	0.86	2.63	1.70	1.34	1.19
MnO	0.02	0.02	0.00	0.14	0.01	0.05	0.05	0.04	0.04
MgO	0.55	0.38	0.23	0.32	0.32	0.70	0.37	0.56	0.46
CaO	1.83	0.81	0.68	0.89	0.88	1.84	1.34	1.27	1.22
Na_2O	3.71	3.20	3.18	2.93	3.20	2.76	2.69	3.82	3.47
K_2O	3.96	5.00	5.19	4.64	4.06	4.66	5.11	4.60	4.43
H_2O-	0.39	0.19	0.30	0.37	0.03	—	—	0.19	—
H_2O+	0.79	0.61	0.30	0.19	—	0.57	0.53	0.10	—
P_2O_5	0.20	0.12	No Anal.	0.23	0.13	0.08	0.14	—	—
Li_2O	0.03	0.40	Ditto	No Anal.	No Anal.	0.03	0.03	No Anal.	No Anal.
B_2O_3	0.01	0.03	Unknown	—	—	0.01	0.03	—	—
F	0.03	0.05	No. Anal.	—	—	Unknown	—	—	—
Other	0.42	0.19	—	0.34	0.52	—	—	0.17	—
Total	99.99	99.60	100.09	100.28	100.25	99.83	100.3	99.96	98.97
a	13.7	13.8	13.6	12.6	12.4	12.6	13.0	14.7	13.7
c	2.1	0.9	0.7	1.0	0.9	2.2	1.6	1.3	1.4
b	4.5	4.6	3.5	4.0	4.2	5.1	3.4	4.7	4.1
s	79.7	80.7	82.2	82.4	82.5	80.1	82.0	79.2	80.8
f′	39.7	27.1	39.8	40.3	28.9	54.5	63.4	44.4	43.0
m′	19.1	12.9	9.1	11.3	10.5	22.0	17.3	16.6	15.8
t	0.3	0.2	0.1	0.1	—	0.3	0.2	0.2	0.2
φ	27.5	17.1	14.5	19.5	12.1	5.2	15.4	19.4	16.0
n	58.8	49.5	47.9	48.9	55.3	47.5	45.0	55.4	54.4
c′	—	—	—	—	—	—	—	—	—
a′	41.2	60.0	51.1	48.4	60.6	23.5	19.3	38.9	41.2
Q	29.5	32.5	36.4	38.4	39.4	32.8	36.4	27.0	33.0
$\frac{a}{c}$	6.5	15.0	19.4	12.6	12.3	5.6	8.1	11.3	9.7

I - Upper Paleozoic tin-bearing granites of the Grodekovsk intrusive complex second phase

II - Upper Paleozoic tin-bearing granites of the Grodekovsk intrusive complex third phase

III - Upper Cretaceous tin-bearing granites of the Maryanovsk intrusive complex

IV - Tertiary tin-bearing alaskitic granites of eastern slope of Sikhote-Alin (according to M.A. Favorsky, 1954)

V - Tertiary leucocratic granites of the eastern slope of Sikhote-Alin (according to F.K. Shipulin, 1954)

VI - Upper Cretaceous tin-bearing granites of the Myao-Chansk intrusive complex second phase

VII - Upper Cretaceous tin-bearing granites of Myao-Chansk intrusive complex third phase

VIII - Mesozoic (lower Cimmerian [Kimmeridgian?]) tin-bearing granites of Zabaykalye according to Iv. F. Grigoryev and Ye. I. Dolomanova, 1953, 1954)

IX - Tin-bearing granites of Kolyma, eastern Siberia, Altay, the Urals, and foreign countries (according to S.D. Popov, 1953).

Thus, comparison of upper Paleozoic tin-bearing granites of Primorye with tin-bearing Mesozoic granites of the Zabaykalye studied in detail by Iv. F. Grigoryev showed that they are distinguished generally from Zabaykalye tin-bearing granites in an especially high content of potassium oxide, by a large value of tourmaline among the diverse accessory minerals, by the absence of rubidium in biotites, by especially large amounts of volatile matter, together with a number of common properties characteristic of tin-bearing granites.

More basic hybrid granitoids are developed, as has been noted above, in separate tin-bearing districts of the Zabaykalye. Tin deposits of two formations are also developed in Kolyma, similar to southern Primorye and Zabaykalye. They are all related to the Upper Cretaceous, although they arose in different times. Deposits of cassiterite-quartz formation are associated with large massifs of acid granites which in general differ little from similar rocks of the other tin-bearing provinces. It is likely that here they have their own distinguishing features which show up in a detailed study of the granites.

Deposits of cassiterite-sulfide formation gravitate in space to relatively small massifs of more basic rocks of hybrid character. They are usually granodorites but even they often contain an increased amount of silica. Granites of the large tin-ore province of Cornwall (England), until recently an important supplier of tin, are sharply separated by an excess, as contrasted with the usual granites, in content of biotite and tourmaline. Biotite contains much lithium, glomeroplasmatically distributed in the rock; this circumstance, in combination with the presence of cordierite, andalusite and garnet among the accessory minerals, indicates contamination developed in these granites.

Besides the above-mentioned accessory minerals, Cornwall granites contain apatite, anatase, rutile, zircon, and cassiterite which is unique compared to other tin-ore provinces. The phenomena of greisenization leading to the origin of schorl-bearing rock, consisting completely of quartz and tourmaline, are also usual in Cornwall granites. Quartz-muscovite greisens are thus rarely formed.

Together with biotite, granite often contains lithionite in another very important tin-ore province of western Europe, in the Rudnyy Mts. Cordierite and garnet occur among the accessory minerals. However, the most distinguishing feature of tin-bearing granites of the Rudnyy Mts., is the wide distribution of greisenization. In places, small massifs of granite are transformed into greisens over the whole area and at a depth to 200 m; the greisens there carry the designation "zwitter". Greisenization of granites is accompanied by the formation of such minerals as topaz, fluorite, beryl muscovite, and others. It is necessary to note that cassiterite was not encountered among the accessory minerals in portions of the granite sufficiently removed from ore bodies and greisenizing zones.

Granites of Malaya, the Dutch Indies, and Indochina are very diverse in structural relation. Of the large-grained and fine-grained, as well as porphyritic granites, the type most distributed there is the one called by Lacroix [20] monzonitic granite with biotite. The list of accessory minerals in granites of this broad tin-bearing region of Asia is distinctive. The list includes: zircon, apatite, topaz, fluorite, which are usual for tin-ore provinces and titanite, ilmenite, magnetite, which are less usual for the province. Here also are developed such sulfides as pyrrhotite, pyrite, and minerals clearly indicating the contamination process in granites, namely cordierite and sillimanite. Here greisens are developed also, but they are localized in narrow zones along cracks in the granites.

Unfortunately, we know little of the properties of comparatively more basic granitoids developed in the Bolivian tin belt. All the above permits confirmation of the fact that features of differences are peculiar not only to tin-bearing intrusions of various tin ore provinces but also to intrusions of different age developed within the limits of the same province. A detailed overall study of the materials composition of tin-bearing intrusions of different age makes it possible to ascertain their petrochemical properties which may serve as one of the criteria in prospecting new tin deposits.

REFERENCES

1. Gotman, Ya. D., K voprosu ob olovonosnykh intruziyakh Primorya [TIN-BEARING INTRUSIONS OF PRIMORYE]: Izv. AN SSSR, ser. geol., no. 6, 1943.

2. Gotman, Ya. D., Intruzii olovorudnykh proyavleniy: Geologiya olova [INTRUSIONS OF TIN ORE MANIFESTATIONS. GEOLOGY OF TIN]: Tr. IGN AN SSSR, ser. rudnykh mestorozhdeniy, vyp. 82, no. 8, 1947.

3. Grigoryev, Iv. F., O kharakternykh priznakah olovonosnykh granitov v rayone Ononskogo i Zun-Undurskogo olovyannykh mestorozhdeniy Vostochnogo Zabaykalya i sravneniye ikh s olovonosnymi granitami drugikh rayonov SSSR. [CHARACTERISTICS OF TIN-BEARING GRANITE FEATURES IN THE ONONSK AND ZUN-UNDURSK DISTRICT OF THE TIN DEPOSIT OF EASTERN ZABAYKALYE AND THEIR COMPARISON WITH TIN-BEARING GRANITES OF OTHER REGIONS OF THE U.S.S.R.]: Tr. MGRI, t. 20, 1940.

4. Levitskiy, O. D., Geologo-petrograficheskу ocherk sherlovoy gory na geologicheskom fronte Vostochnoy Sibirii. [GEOLOGIC PETROGRAPHIC SKETCHES OF SCHORL-BEARING MOUNTAINS IN EASTERN SIBERIAN GEOLOGIC FRONT]: Irkutsk, 1933.

5. Preobrazhensky, I. A., Olovonosnyye granitoidy Borshchelo-vochnogo khrebta. [TIN-BEARING GRANITOIDS OF THE BORSHCHELOVOCHNY RANGE]: Tr. Petrogr. in-ta AN SSSR, vyp. 14, 1939.

6. Rub, M. G., Granity grodekovskogo i maryanovskogo intruzivnykh kompletksov v Yuzhnom Primorye i osnovnyye cherty ikh metallonosnosti [GRANITES OF THE GRODEKOVSK AND MARYANOVSK IN-COMPLEXES IN SOUTHERN PRIMORYE AND BASIC FEATURES OF THEIR METAL-BEARING CHARACTER]: Tr. IGYeM AN SSSR, vyp. 3, 1956.

7. [There is no Reference 7 listed in Russian original].

8. Rub, M. G., Greyzeny Yugo-Zapadnogo Primorya i ikh genezis. [GREISENS OF SOUTHWESTERN PRIMORYE AND THEIR GENESIS]: Tr. IGYeM AN SSSR, vyp. 5, 1957.

9. Smorchkov, I. Ye., Kislyye intruzii Zerenskogo rayona (Vostochnoye Zabaykalye) B svyazi s ikh olovonosnostyu [ACID INTRUSIONS OF ZERENSKY DISTRICT (EASTERN TRANS-BAIKAL) IN CONNECTION WITH THEIR TIN-BEARING CHARACTER]: Tr. IGI AN SSSR, ser. petrogr. vyp. 55, No. 16, 1941.

10. Favorskaya, M. A., O svyazi olovonosnogo orudneniya s magmatizmom [CONNECTION OF TIN-BEARING MINERALIZATION WITH MAGMATISM]: Izv. AN SSSR, ser. geol., No. 4, 1955.

11. Favorskaya, M. A., Verkhnemelovoy i kayinozoysky magmatism vostochnogo skona Sikhote-Alin [UPPER CRETACEOUS AND CENOZOIC MAGMATISM OF EASTERN SLOPE OF SIKHOTE-ALIN]: AN SSSR, 1956.

12. Shipulin, F. K., Tretichnyye granitoidy Yuzhnogo Primorya i nekotoryye dannyye po ikh metallogenii [TERTIARY GRANITOIDS OF SOUTHERN PRIMORYE AND CERTAIN DATA ON ITS METALLOGENE CHARACTER]: Izv. AN SSSR, ser. geol., No. 5, 1950.

13. Ahfeld, F., THE BOLIVIAN TIN BELT: Econ. Geol. No. 31, 1936.

14. Chatterjee, M., THE ACCESSORY MINERAL ASSEMBLAGE OF THE BODMIN MOOR GRANITE (CORNWALL): Proc. Geol. Assoc. London, 40, 147-152, 1929.

15. Dewey, G. S., THE MINERAL ZONES OF CORNWALL Proc. Geol. Assoc. London, 36, 2, 1925.

16. Ferguson, H. G., Bateman, A. M., GEOLOGIC FEATURES OF TIN DEPOSITS. Econ. Geol: 7? 210-262, 1912.

17. Fritzsche, E., BEITRAG ZUR PETROCHEMISCHEN KENNTNIS DER ERZGEBIRGISCHEN GRANIT MASSIVE: N. Jg. min. A. B. B. v. 58, pp. 253-302, 1928.

18. Ghosh, P. K., THE MINERAL ASSEMBLAGE OF THE FALMOUTH GRANITE (CORNWALL): Proc. Geol. Assoc. London, v. 39, pp. 332-338, 1929.

19. Groves, THE HEAVY MINERALS SUITES AND CORRELATION OF THE GRANITES OF NORTHERN BRITTANY, THE CHANNEL ISLAND AND THE COTENTIN: Geol. Mag. v. 67, pp. 218-240, 1930.

20. Lacroix, A., CONTRIBUTION A LA CONNAISSANCE DE LA COMPOSITION CHIMIQUE ET MINERALOGIQUE DES ROCHES ERUPTIVES DE L'INDOCHINE: Hanoi, 1933.

21. MacAlister, D. A., GEOL. ASPECT OF THE LODES OF CORNWALL: Econ. Geol. No. 5, p 363, 1908.

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BASIC PHASES OF THE GEOTECTONIC DEVELOPMENT OF THE AZOV-KUBAN DEPRESSION[1]

by

A.V. Chekunov

REVIEWER'S NOTE

Gives an interesting account of the sedimentary tectonics of an important region, also of the formation and genetic relations of several fold systems. Promulgates some fresh ideas not given much attention in the United States.

ABSTRACT

The history of the Azov-Kuban submontane depression and the specific features of its geotectonic evolution are given on basis of the abundant geological and geophysical data available. The geotectonic plan and environment of the depression in the course of its development underwent rather considerable alterations. Throughout the territory under consideration these alterations were manifested nonuniformly. Accordingly the author distinguishes four principal stages in the formation of the Azov-Kuban depression and gives a brief characteristic of each stage. --Auth. English Summ.

* * *

In recent years there has been considerable progress in understanding the geology of the Azov-Kuban depression. The literature contains a reasonably complete analysis of the tectonic structure of the region and the geological history of several of its parts has been clarified [5 through 9, 11, 12, 19, 20, 25, 27, 35, 36, 37]. Yet, there has not been adequate elaboration of questions of the geotectonic development of the entire Azov-Kuban depression, although they have been touched upon in the works mentioned.

In 1955-1957, the author undertook to publish the extensive material accumulated up to that time on the geology of the Azov-Kuban depression. He dealt primarily with the history of geotectonic development of the depression.

Certain results of the investigation have already been elucidated by us. We have examined, for instance, the geotectonic development of a component part of the Azov-Kuban depression, the Indol-Kuban (Krym-Kavkaz) foredeep, [32 and others]. In the present article we attempt to analyze the geotectonic evolution of the whole Azov-Kuban depression and project the bases of its laws.

It has been assumed that the Azov-Kuban (or Kuban-Azov) depression was first delineated by A. D. Arkhangelskiy in 1941 [2, p. 246]. This, however, was not the first recognition of it as a unique feature. In general outline it was perceived in 1888 by I. I. Andrusov [1, Table I, p. 97]. In 1933 this depression was identified by D. N. Sobolev as an independent basin, and, was, apparently for the first time, called the Azov-Kuban [23, Table III]. In the same year K. I. Lisitsyn [13] distinguished three depressions in the northwest and central Caucasus area, one of which he termed the Priazov-Kuban. In 1941 the Azov-Kuban depression was defined by A. D. Arkhangelskiy [2, p. 246], M. N. Pukhtinskiy [21, p. 172] and once again by D. N. Sobolev [24 p. 90], while A. D. Arkhangelskiy factually relegated it to the Black Sea depression [2, p. 65]. The need to delineate the Azov-Kuban depression was posed with the greatest precision by M. V. Muratov [17] in 1946.

At the present time certain investigators [8, 19, 27, 35 and others] consider that the very notion of an "Azov-Kuban depression" is untenable, unnecessary, and eliminated itself. However, these investigators fail to recognize its structure and genetic unity. They greatly exaggerate the role of its component parts, particularly the hidden ideas which should appear as elements of subordinate rank with respect to the total depression.

Within the Greater Caucasus, as is well-known, are many anticlines and synclines [28], quite varied in structure, tectonic history, and individual characteristics. From this, however, no one could conclude that it is necessary to abolish the geanticline of the Greater Caucasus. The concept of the Azov-Kuban depression as a distinct structural unit of a young depression zone including within itself a series of buried Mesozoic-Paleogene structural elements, is logical and can be maintained [31].

A series of peculiarities in the development of the Azov-Kuban depression during the Alpine orogeny permits some conclusions relating to certain geotectonic traits of the territory under discussion in the Hercynian.

[1]Sovetskaya Geologiya, 1960, no. 2, pp. 57-73.

At present it is difficult to delineate even the most important anticlines and synclines within the Hercynian folded structure buried at depth in the Azov-Kuban depression. The available geological information presents too few possibilities in this connection. More useful are seismic data reconnaissance which throw light on the structure of lower horizons of the Azov-Kuban depression, which are directly upon or close to the basement. In this portion, which has a Hercynian basement the structures in the lower horizons correspond, obviously, to the sections intensively raised in the Hercynian stage and to a slowly continued, gradually diminished, relative arching in the latter: the Alpine stage of development. A similar inheritance of tectonic movements by one stage from another within the borders of young platforms is well known. N. S. Shatskiy [34], A. L. Yanshin [38] and others have determined the character of the Hercynian tectonic structure proceeding from a study of the tectonics of a Mesozoic-Cenozoic cover and guided by the principle of the inherited development of structures. In conformity with the plains areas which separate the Russian platform from the mountainous structures of the Crimea and the Caucasus, the notion of the correspondence of important positive structural forms of platform (swells) most intensively uplifted in the Hercynian stage was expressed not long ago by M. V. Muratov [19].

The following peculiarities are observed in the expanses of the positive structures of the platform portion of the Azov-Kuban depression and the adjacent areas (see fig. 7). We observe a parallel between the buried Hercynian massif of the Crimea and the Kanevsko-Adygey swell of the northwestern Caucasus area. The Hercynian massif of the Crimea extends, obviously, from the Zuya River to the northwest through the Simferopol projection to the eastern portion of the Tarkhankut swell (Novoselov structure), where it changes its direction to one close to the latitudinal. The Adygey and Berezan projections of the Kanev-Adygey swell, appearing as a continuation of each other, possess a general northwest extension, parallel to that of the Hercynian massif of the Steppe Crimea. Following upon the Berezan projection, the Kanev uplift has a nearly latitudinal orientation. It is entirely possible that in the given instance we have buried Hercynian anticlines parallel to each other, the general orientation of which in the degree of approach to the Ukrainian crystalline massif, and, obviously, under the influence of the latter, is exchanged from northwest to latitudinal.

The Kanev-Adygey swell and the Salskoye uplift, as well as the Severo-Stavropol swell, which is parallel to the latter, skirt the area of the subterranean extension of the Ukrainian crystalline massif, which embraces the region of the city of Rostov, the areas south and southeast of it, and possibly includes within itself the Kalnibolot projection. All this indicates that the territory of the Ukrainian crystalline massif at the time of the Hercynian folding was relatively stable [2, p. 212].

It is possible to draw two preliminary conclusions from all that has been said. First, the general orientations of the Alpine folded zones of the Crimea and the northwest Caucasus do not follow upon the Hercynian orientations but are disposed with respect to them at considerable angles. Second, the orientations of Hercynian structures of relatively Alpine nature are obviously more meridional.

Turning to an examination of the Alpine stage, it is first of all necessary to note that the peculiarities of development of foredeeps and depressions near mountains cannot correctly be construed separate from the circumstances produced in the formation of their geosynclines. We shall refer constantly to the tectonic history bound up with the Azov-Kuban depression of Alpine geosynclines [3, 10, 18, 26, 29 and others]. By way of illustration the article contains six isopach maps (see fig. 1-6), permitting one to trace the phases of the geotectonic development of the depression.

Under the influence of the developing geosynclinal subsidence of the Crimea and the northwest Caucasus, the geosynclinal regime established as the result of a Hercynian stage on a large part of the territory now occupied by the Azov-Kuban depression is replaced, in various districts and at various times, by a regime of outgoing movement. In the Middle Jurassic(?) epoch, obviously, the process of deposition of the Azov-Kuban depression is begun. Deposits conditionally related to the Dogger are laid down in the Steppe Crimea on Paleozoic rocks. We shall begin our examination of the Alpine history of the district from the time of their accumulation.

Substantial changes which interrupted the geotectonic plan of the Azov-Kuban depression during the process of its development, impel us to break down the whole history of the formation of the depression into four main phases.

1) Middle Jurassic(?) - Upper Cretaceous (see figs. 1 and 2). As the first appearance of the noted process of the total inversion of the Crimean geosyncline in the Alpine stage there was a cessation of the basic Tavricheskoye flysch fold, taking place at the end of the Lower Jurassic. Active arching of the uplift continued in the Dogger, arising within the borders of the subsidence at the end of the Lias. It was accompanied by intensive folding, strong volcanic activity and the appearance north of the uplift of a compensatory foredeep. Obviously, the greater portion of the latter was disposed along the periphery of the preinversion Tavricheskiy

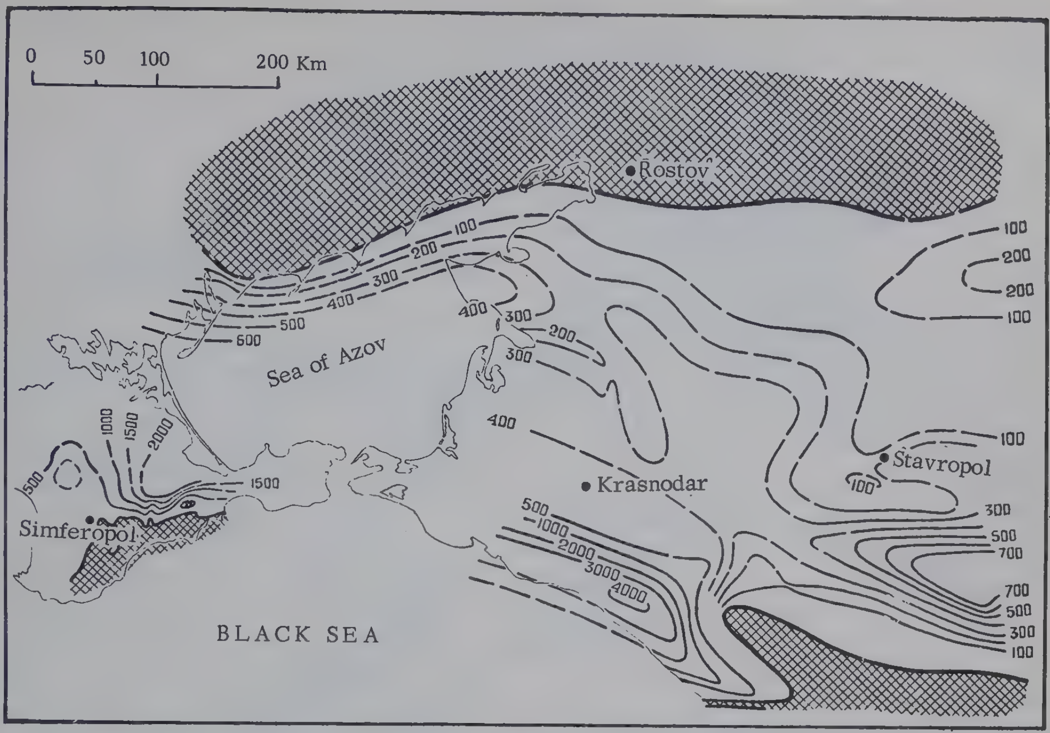

FIGURE 1. Schematic map of equivalent thicknesses of Lower Cretaceous deposits

1 - areas lacking deposits

200 2 - isopachs

subsidence. The composition of the detritus of conglomerates (Bitak) filling this subsidence, just as of the detritus of the Upper Jurassic and Lower Cretaceous conglomerates of the Crimea (fragments of quartzites, phyllites and granites), bears witness to the fact that in the central portions of the uplift, perhaps those south of the Crimean Peninsula in the area now occupied by the Black Sea, certain ancient (Paleozoic?) metamorphic rocks and granites were laid bare and subjected to intensive erosion.

As a result of uplifts which appeared within the borders of the Tavricheskiy subsidence, portions of the epi-Hercynian platform which lie towards the Crimean geosyncline from the north, are, in the Dogger, drawn into the subsidence. This in itself marked the beginning of the process of formation of the submontane Azov-Kuban depression.

Subsidence predominates in the geosynclines of the Caucasus during the Middle Jurassic; a geotectonic differentiation is produced, as is a complication and breaking up of subsidences [29].

In the Malm the process continues of closing the geosynclinal subsidences of the Crimea. Thus, at the end of the Lusitanian the East Crimean intrageosyncline is closed, in the place of which arises the Sudak-Karadag folded zone, joined to the Tuak intrageanticline and augmenting it towards the northeast. A foredeep is formed north of the Sudak-Karadag zone during the Kimmeridgian-Tithonian, completed in the southern portion by a thick layer of conglomerates (800 meters), along the axis by a carbonate flysch (as thick as 2,500 meters) and in the north predominantly by limestones marking the platform side of the subsidence. Subsidences embrace all the new extensions of the Steppe Crimea.

Within the borders of the Caucasus geosyncline during the Upper Jurassic, geotectonic dismemberment is sharply increased and an intensive flysch regime sets in [26, 29]. It is interesting to note that in the Crimean geosynclines it is produced basically in the Triassic-Lower Jurassic (Tavricheskiy suite), and on the boundary of the Upper Jurassic and Lower Cretaceous, it is actually brought to an end.

In the Neocomian the foredeep of the East Crimea is significantly displaced towards the north, in the region of the Kimmeridigian-Tithonian platform wing; this marked the beginning of the existence of the Indol subsidence in the contemporary sense. By the Lower Cretaceous signs are noted of a certain displacement of the

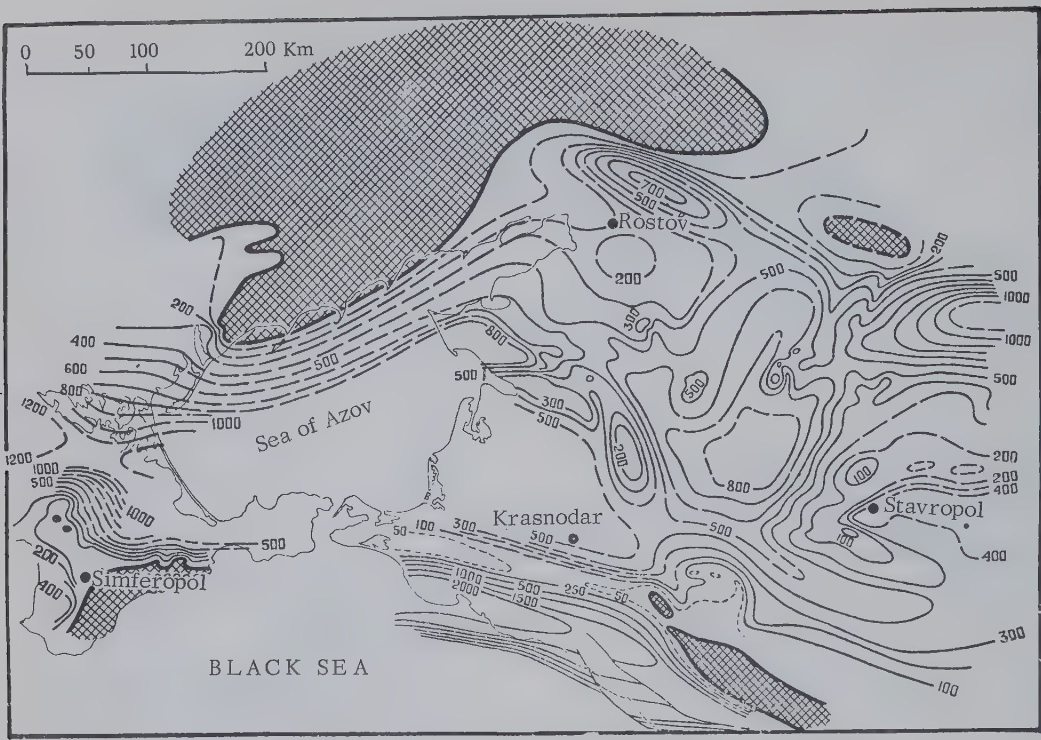

FIGURE 2. Schematic map of equivalent thicknesses of Upper Cretaceous deposits

1 - areas lacking deposits

2 - isopachs

foredeep towards the east along its extension, which appears later so strongly.

The territory which the foredeep occupied in the Kimmeridgian-Tithonian includes the general uplift of the folded zone of the Crimea, and is formed by the Upper Albian into the East Crimean syncline [18].

Within the borders of the geosyncline of the Greater Caucasus in the Lower Cretaceous no notable deviations from the geotectonic plan [29] take place. In the Northwest Caucasus the formation of a geosynclinal flysch subsidence continues. However, at this time signs begin to appear of the final stages in the geosynclinal development. This is attested by the advance of the sea from the limits of the geosyncline to the north, conditioned by the exchange of the upward movements by downward ones on the broad expanses of the epi -Hercynian geanticline and in the border portions of the Ukrainian crystalline massif. In the Upper Cretaceous the transgression achieves its maximum.

No very substantial reorientations of the tectonic plan were produced at this time in the Caucasus geosyncline. Within the borders of the geosynclinal subsidence of the Northwest Caucasus, bordered on the north by the Kuban-Adyge Range Cordillera, the flysch regime still continues.

In the platform portion of the Azov-Kuban depression during the course of the Upper Cretaceous, the influence of an earlier, probably Hercynian, tectonic plan is distinctly expressed, conditioned by the division of the territory in question into a series of subordinate uplifts and subsidences.

The characteristic trait of the Upper Cretaceous in the regions under discussion is the geotectonic leveling conditioned almost everywhere by the accumulation of carbonate layers which are lithologically of a single type. Not less characteristic is the broad territorial distribution of intensive subsidences, concentrated earlier exclusively within the bounds of the Caucasus geosyncline, but now embracing a significant expanse of the adjacent portions of the platform. The speed of the negative movements within the borders proper of the geosynclinal subsidence of the Northwest Caucasus falls off and becomes commensurable with the speeds of sinking of newly risen adjacent platform subsidences. Thus, the contrasts of movements in the geosynclinal and the platform subsidences

are smoothed out, and intensive subsidences embrace a broad area.

By the end of the Upper Cretaceous in the platform portion of the Azov-Kuban depression there was in many districts a leveling of the geotectonic regime which had earlier been more differentiated. This is associated, evidently, with the gradual attenuation of the inherited post-Hercynian movements which succeed all rising consolidation of a young epi-Hercynian platform.

In the course of the Upper Cretaceous the remaining districts of the Azov-Kuban depression, which had remained elevated until this time, were drawn into subsidence. Thus, the process is completed of the formation of the Azov-Kuban depression, a process which began in the Crimea in the Middle Jurassic(?).

The various portions of this depression are of different ages: In the Jurassic period the Crimean portion was formed, and, probably, the southern periphery in the Northwestern Pricaucasus, coinciding evidently with the border portions of the Jurassic geosynclinal subsidences of the Northwest Caucasus; the greater part of the territory of the depression was formed in the Albian age, and its northern border districts were formed in the Upper Cretaceous. In the Northwest Caucasus the foredeep proper does not exist in the Upper Cretaceous.

2) The Paleocene-Eocene (fig. 3). A reorientation of tectonic plan took place on the border of the Upper Cretaceous and the Paleogene in the Northwestern Caucasus, and intensive positive movements appeared [29]. The flysch-type subsidence shifted to the north (V. A. Grosgeym and others), and in the lower Paleocene by its geotectonic activity was converted into a foredeep. At this time at places of Upper Cretaceous flysch subsidence there is formed an uplift which, obviously, is joined with the inner intrageanticline noticeable in the Liassic geosyncline of the Northern Caucasus [26]. In the foredeep which arose in the course of the Paleocene and part of the lower Eocene there was produced a flysch regime. The role of coarse-fragmental terrigenous material was significant on the inner side of the subsidence.

All of the adduced facts attest the clearly marked asynchronous development of the geosynclinal subsidences of the Crimea and the Greater Caucasus, notwithstanding the fact that these subsidences are adjacent and belong to a single geosynclinal territory; or, possibly, to two neighboring geosynclinal territories: the Crimean and the Caucasian.

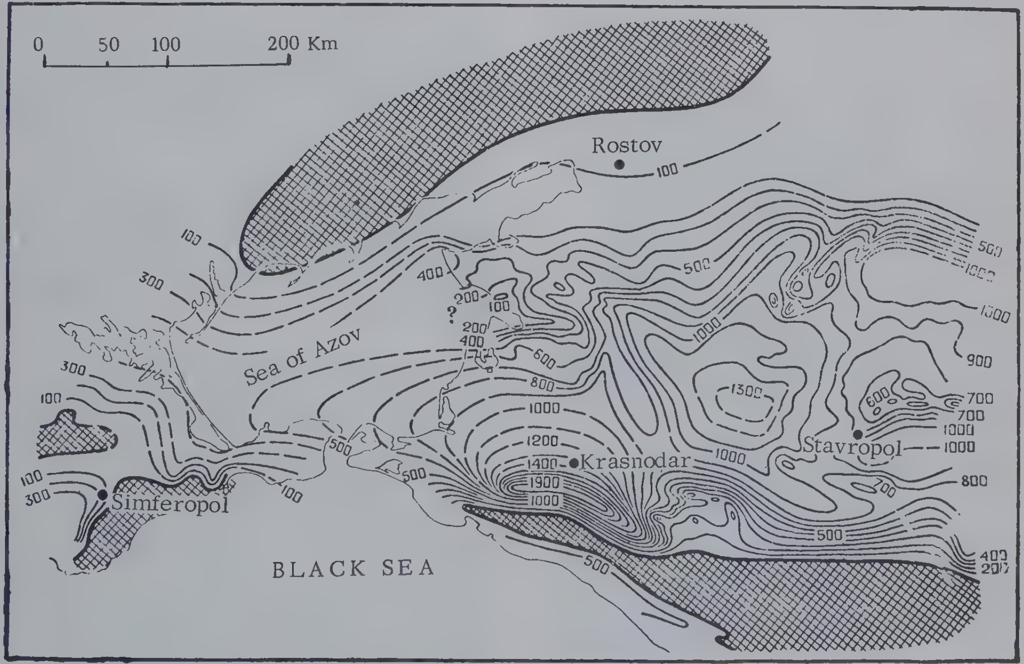

FIGURE 3. Schematic map of equivalent thicknesses of Paleocene-Eocene deposits

1 - areas lacking deposits

2 - isopachs

This difference places an important role in the geotectonic life of the Crimea-Caucasus (Indolo-Kuban) foredeep. Investigators have long known the tectonic variations of the mountainous structures of the Crimea and the Caucasus. It was just this which prompted E. Seuss [39], A. D. Arkhangelskiy [2], A. N. Mazarovich [15] and other investigators to relate the mountainous Crimea to the Mesozoic (Kimmeridgian, Yenshanian, Pacific Ocean) folding, while A. D. Arkhangelskiy regarded it separately from the Caucasus [2, p. 226]. V. P. Rengarten, as is well known, related the mountainous Crimea to the Transcaucasus platform [22, p. 187], while A. N. Mazarovich, emphasizing the tectonic distinctions between the Crimea and the Caucasus mountain structures, [14, p. 249] related the Crimean Yayla (with the Middle Jurassic) to the category distinguished by himself of platform tectonic structures - the "regional plate," [14, p. 23], considering that the deposits which are younger than the Lower Jurassic appear as platforms [14, p.186]. V. V. Beloussov was inclined to identify the folding of the mountainous Caucasus as "parageosynclinal" [4].

In connection with the appearance of the foredeep of the Northwest Caucasus area in the lower Paleocene, substantial changes are undergone by the geotectonic regime of the Indol trough, which was actually interrupted in the platform stage. The region of greatest subsidence and the center of tectonic activity are transferred into the zone of the foredeep of the Northwest Caucasus area.

In the lower Eocene substantial alterations take place in the geotectonic regime of the subsidence. The flysch regime is transformed (in the foredeep area of the East Crimea it was cut short before the Lower Cretaceous) while the zone of maximal subsidences proves to be shifted to the southeast along the axis of the folded zone of the Caucasus. At this time subsidence in the area where it was maximal in the Paleocene, slows down and undergoes folding, forming in the contemporary structure of the foredeep a zone of buried folding of geosynclinal type (the district of Stanitsa Krymskaya and Stanitsa Azovskaya).

In the upper Eocene, subsidence in the southeast of the forward fold slow down and there is produced a leveling of the geotectonic regime in various districts of the subsidence. In the Indol subsidence during the course of the whole Eocene the regime established already in the Paleocene (and, possible, in the Upper Cretaceous), close to the platform type, continues to be dominant.

The geotectonic leveling noted by the end of the Eocene in the Northwest Caucasus area and in the Crimea, analogously to the geotectonic levelling of the Upper Cretaceous epoch, preceded a major reconstruction of tectonic plan that occurred later on the border of the Eocene and the Oligocene. Like the Upper Cretaceous, the upper Eocene geotectonic leveling was also accompanied by maximum transgression.

In the platform part of the Azov-Kuban depression the process continued of the weakening of tectonic movements and the leveling of geotectonic regime of various places, already noted in the Upper Cretaceous. By the end of the Eocene the Yeysk subsidence came to an end and the relative uplift of the Kanev and Berezanskoye structures had come to an end, as a consequence of which the East Kuban subsidence lost its independence, blending with the Indol-Kuban, while the Kalnibolota projection ceased. Later on, the northern platform side of the Azov-Kuban depression assumed in general outline the form of a solitary consolidated block. Simultaneously the Stavropol elevation and the structures associated with it (the Salsk elevation and the Rasshevat projection) continued their development.

Therefore, from the border of the Upper Cretaceous and the Paleocene (that is, from the moment when upward movements began to predominate and a transformation began in the folded zone of the geosynclinal subsidence of the Northwest Caucasus) up to the Anthropogene, there began to take place a constant tendency towards increase of contrast of tectonic movements within the borders of the Azov-Kuban depression, a tendency created by the steadfast weakening and leveling of the downward movements in the platform portion of the depression and by a concentration and strengthening of them exclusively within the borders of the foredeep. Comparatively intensive subsidence in the marginal portion of the platform is discontinued, being concentrated directly at the base of the geanticlinoria of the Greater Caucasus. On the whole territory of the depression the process in question following the Maykop is firmly accompanied by a tendency towards the establishment of geanticlinal conditions.

3) The Oligocene-Lower Miocene (fig. 4). On the border of the Eocene and the Oligocene still another reconstruction of the tectonic plan takes place within the borders of the foredeep. During Maykop time the foredeep, reacting to the increase in uplift of the folded structures of the Crimea and the Caucasus, becomes still more intensively submerged. Active heaving of geanticlines causes deposition in the neighboring depressions of a vast amount of terrigenous material, from this moment and up to the Anthropogene predominating sharply in the composition of deposits of the Azov-Kuban depression.

A significant condition on the border of the Eocene and the Oligocene was the appearance of deep subsidences in the borders of the Indol subsidence continuing into the Paleocene and Eocene

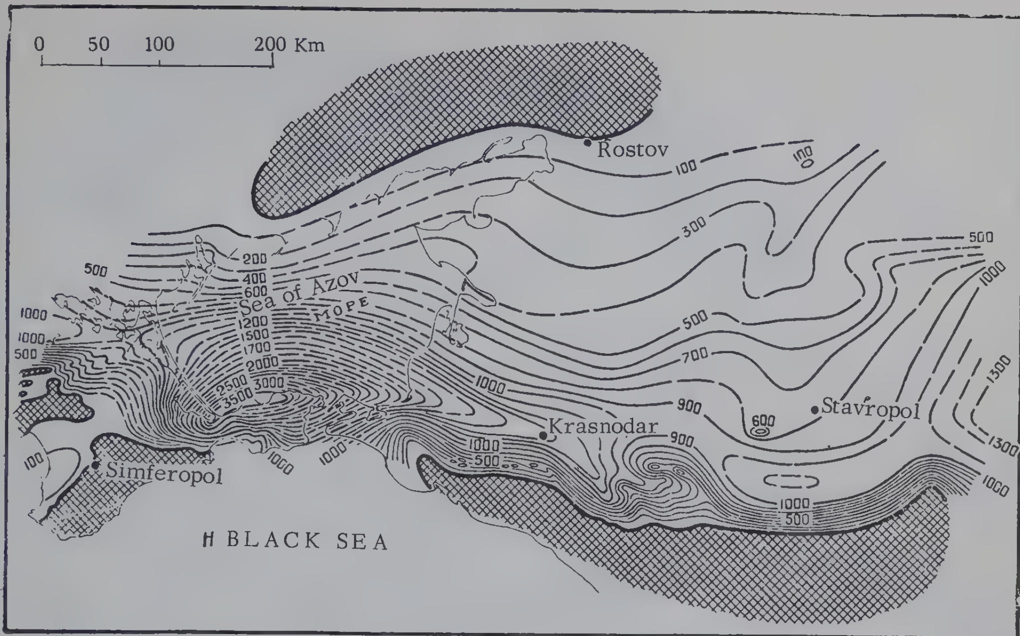

FIGURE 4. Schematic map of equivalent thicknesses of deposits of the Oligocene-Lower Miocene

1 - areas lacking deposits

2 - isopachs

close to the platform type. The area of maximal subsidence in Maykop time proves to be substantially shifted to the east with respect to that of the Lower Cretaceous – a fact evidently associated with the general arching uplift of the Crimea.

Within the borders of the Kuban depression there also took place a significant subsidence, but one much less intensive than that in the Crimea. In the zone of folding which developed at the site of a flysch Paleocene-Lower Eocene subsidence (the district of Stanitsa Krymskaya-Stanitsa Azovskaya) on the border of the Eocene and the Maykop the growth of folds was sharply increased, having assumed an intermittent character, which led to the formation of complex structures of geosynclinal type. The comparatively slow growth of the latter was finally cut short in the Maykop. Simultaneously we observe a dislocation of the folding-type processes towards the north in a direction from the folded zone towards the platform. Thus, in the Maykop time in the axial zone of the Caucasus area portion of the foredeep, and within the borders of the Taman and Kerch peninsulas, as change takes place, and there begins (in places the slow growth continues) of brachyanticlinal folds, grouped in sharp anticlinal lines in the south and distributed more irregularly in the north.

4) The Middle Miocene-Anthropogene (fig. 5 and 6). A substantial alteration of geotectonic plan is newly produced on the border of the Maykop and the middle Miocene, within the borders of the foredeep. The intensive Maykopian subsidences in the Indol fold died out, being finally replaced by a platform regime, the first symptoms of which were already noted in the Paleocene-Eocene, but possibly even in the Upper Cretaceous. In the Neogene, beginning with the middle Miocene, the Indol subsidence by its geotectonic regime is more like a syneclise (which, properly speaking it becomes) than a foredeep.

The area of intensive subsidences from the territory of the Crimea (being preserved for a designated time only in the southeastern and extreme eastern parts of the Kerch peninsula) is newly transferred to the territory of the Northwest pre-Caucasus, embracing from the north and northwest the northwestern pericline of the intensively uplifted geanticlinorium of the Greater Caucasus. Beginning with the middle Miocene the western part of the foredeep is located not within the borders of the Indol subsidence, as it had been previously assumed [19 and others], but within the borders of the Taman peninsula; the subsidence opens on the side of the Black Sea.

In the axial portion of the foredeep, in the Caucasus area in the middle Miocene there took place a relative growth of central uplift (Anastasiyevo-Krasnodar) of significant dimensions, accompanied by folding. The intensity of uplift and of the folds located within its bound-

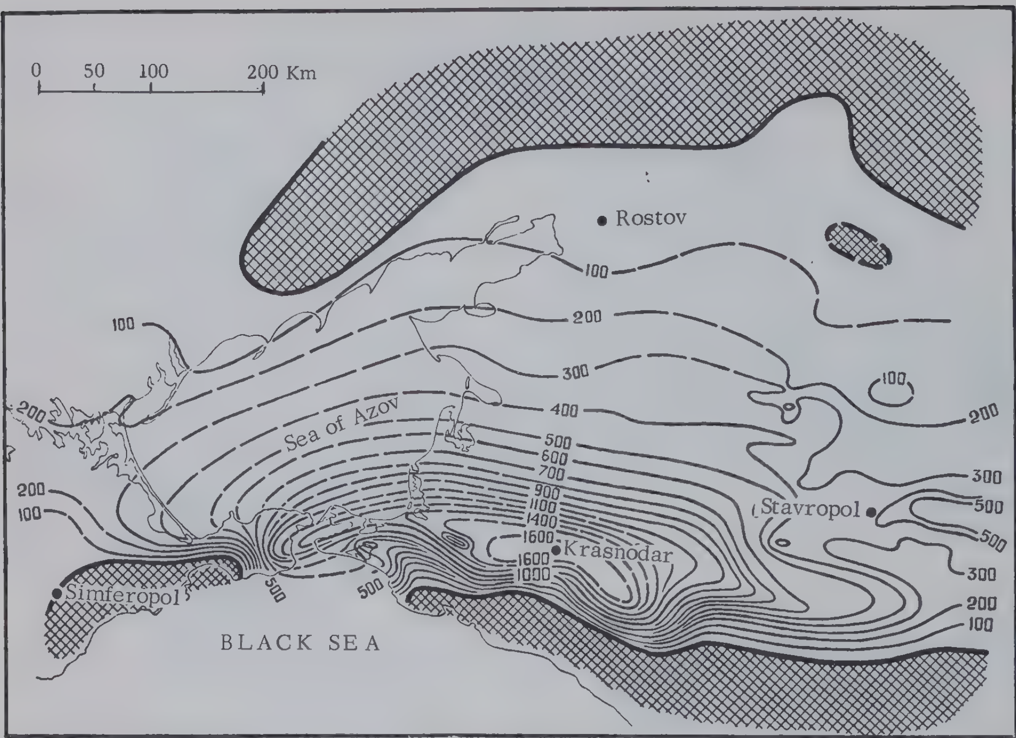

FIGURE 5. Schematic map of equivalent layers of Middle-Upper Miocene

1 - areas lacking deposits   200 2 - isopachs

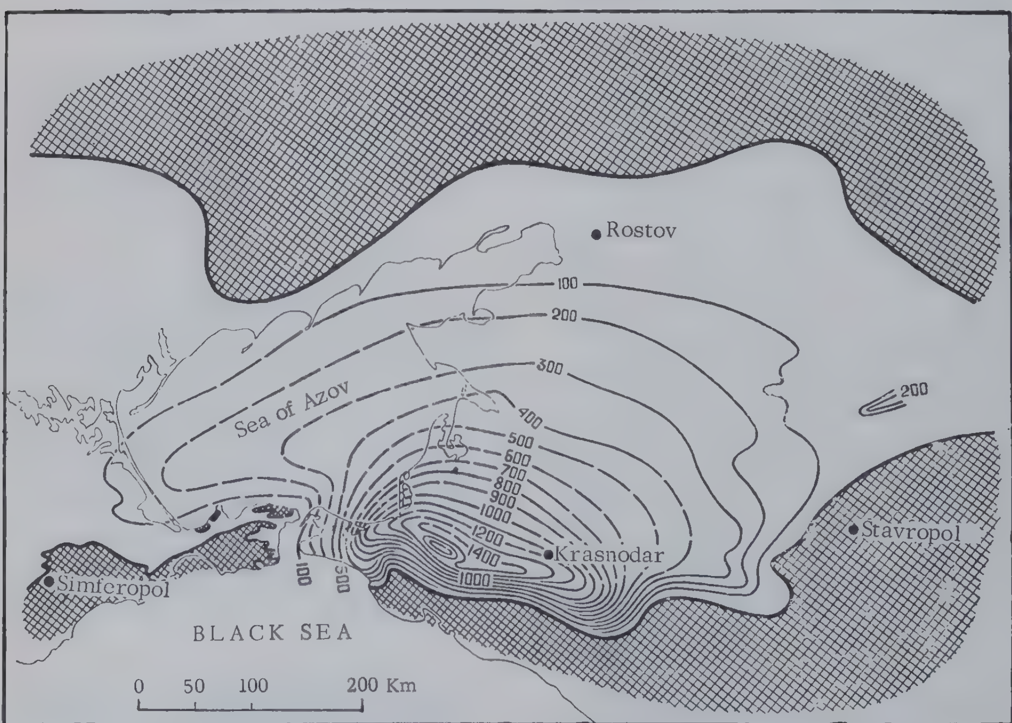

FIGURE 6. Schematic map of equivalent thicknesses of Pliocene deposits

1 - areas lacking deposits   200 2 - isopachs

aries varied over the extent of the uplift and was directly proportional to the intensity of the subsidence of other parts of the feature.

The formation of the Anastasiyevo-Krasnodar central uplift went no further than an embryonic stage; within its borders at the end of the Miocene only individual folds continued growing (I. P. Zhabrev, 1957).

Geanticlinal conditions generally set in during Miocene and Pliocene in the Azov-Kuban depression. Over this expanse of time a successive shortening of dimensions both of the zone of maximal subsidences and of the whole subsidence at the expense of its peripheral areas was observed along with gradually decelerating tempos of subsidence accompanied in places by the uplift of adjacent geanticlines. In connection with the previously mentioned process of general strengthening of geanticlinal tendencies, the dimensions of the sea basin located within the Azov-Kuban depression were contracted and, correspondingly, the area where continental conditions existed was increased. During the Anthropogene the geotectonic plan and regime established by the end of the Pliocene underwent four principal changes.

From all that has been adduced above, it has been possible to reach the following conclusions:

1) In the structural sense, and from the point of view of the history of geological development, particularly in the Neogene, the Azov-Kuban depression presents itself as a unique important geosyncline. It is a component part in a chain of submontane subsidences, which extends along the northern border of the Alpine geosynclinal belt. A belt of subsidence within the geosyncline distinguished it from the platform areas located further north. Within the borders of the depression are distinctly set off a foredeep zone and, adjacent to it, an area of typical platform type involved in subsidence.

2) The Azov-Kuban depression developed as the result of compensatory subsidences of the Alpine orogeny. It developed on a heterogeneous basis consisting of structures of various age. The latter present themselves as a post-Proterozoic platform in the north, as a Hercynian folded structure over the greater part of the territory of the depression, as a Taurian and Paleocene-lower Eocene flysch subsidence within the borders of the contemporary inner side of the foredeep in the Crimea and in the Northwest Caucasus area.

3) The geotectonic position of the depression is quite specific. It was formed by a junction of young Alpine geosynclines developed individually and asynchronously (a fact of quite considerable importance) and of an epi-Hercynian platform in direct contiguity with a Precambrian platform. This circumstance conditioned the peculiar character and very complicated history of the geotectonic development of the depression. Its territory has appeared as its own special type of an interferential field, within whose borders active influences of young Alpine geosynclines of the Crimea and the Caucasus have exercised a summary influence of the expiring inherited post-Hercynian movements on a large part of the territory of the depression and the stability of the Ukrainian shield which lies to the north.

4) The basic component part of the Azov-Kuban depression is the Crimea-Caucasus (Indolo-Kuban) foredeep, which presents itself as a rudimentary geosynclinal subsidence of the Crimea-Caucasus geosynclinal district, a significant part of which has developed within the borders of the platform and which has continually exerted an influence on its neighboring portion. The appearance and development of this subsidence was conditioned by the tectonic life and influence of the geosynclines both of the Crimea and of the North Caucasus. It is characterized by great amplitude, and, consequently, great rate of subsidence, as well as significant gradients thereof, especially in the borders of the southern portion.

5) The asynchronism of the development of the geosynclines of the Crimea and the Greater Caucasus conditioned the various ages of the foredeep in the Crimea (Middle Jurassic(?), distinctly – Kimmeridgian-Tithonian) and in the Northwest Caucasus area (Paleocene) and the variable stage of influence on the development of the subsidence of each of the designated geosynclines at various times: an exclusive influence of the Crimean on the Mesozoic, and, predominating, in the Maykopian; the predominating influence of the Caucasus in the Paleocene, Eocene, Middle and upper Miocene, Pliocene and Anthropogene. With this, the zone of maximal subsidence over the extent of geological history of the development of the foredeep has repeatedly and sharply changed its position, trying out significant shifts and drawing to itself this or another geosyncline. At the same time when subsiding in the Caucasus area would be strengthened, sinking in the Crimea would be weaker, and vice-versa.

6) The peculiarities of tectonic development of the foredeep, characterized above, lead us to the conclusion that this subsidence, unique in a structural sense and deeply prognathous, obviously can be regarded as a united structural form which arose as a consequence of the development of two foredeeps: the Eastern Crimean and the Western Caucasian, the first of which is older. The development of these two subsidences was, however, not strictly autonomous, but interdependent. Let us consider it possible to suggest [32] a new name for the structure of the foredeep – the "Crimean-Caucasian."

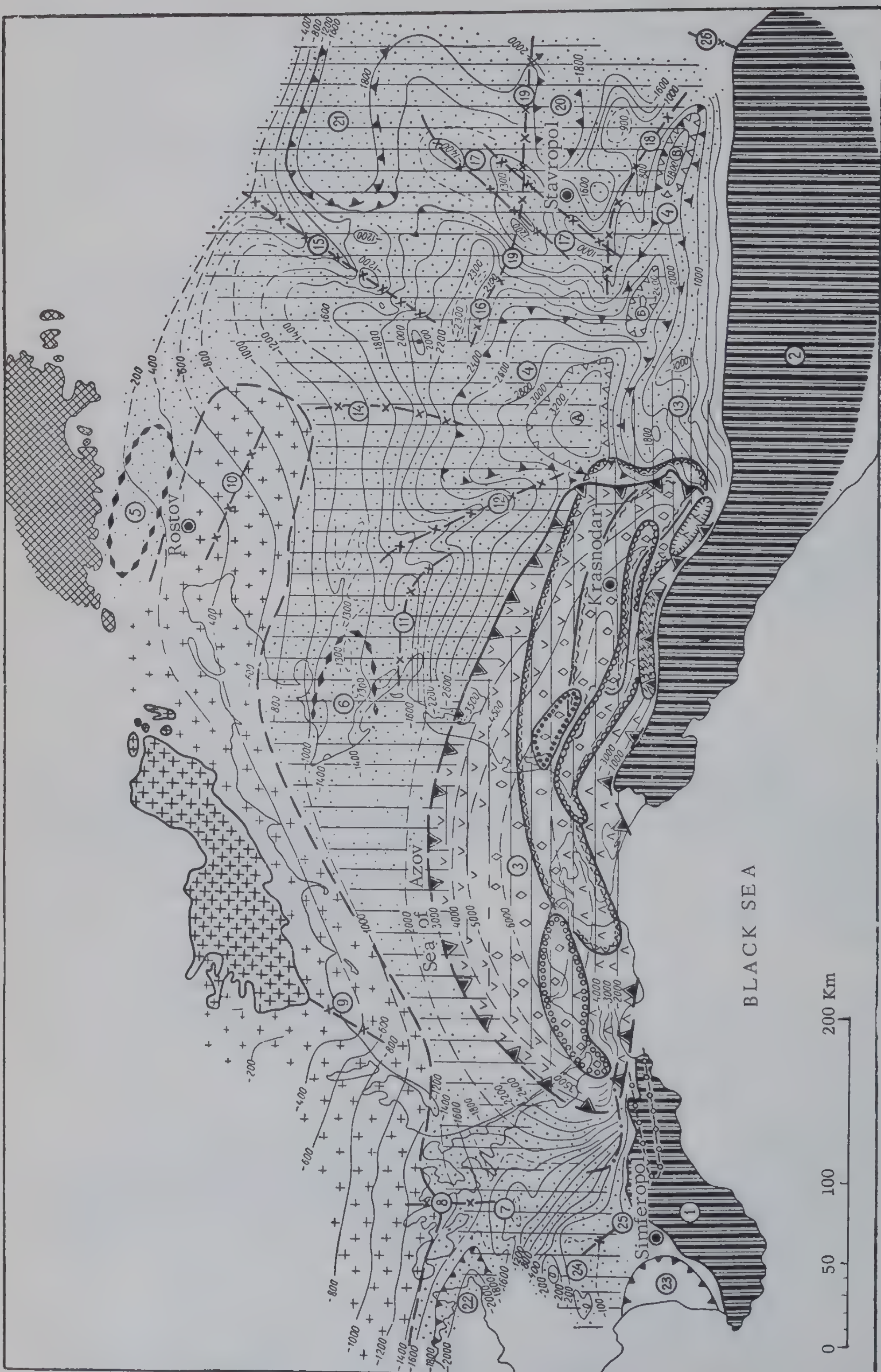

FIGURE 7. Tectonic scheme of the territory of the Azov-Kuban depression and adjacent regions (1957)

Legend

1 - Alpine geanticlinorium

2 - Alpine foredeep (Crimean-Caucasian)
- a - inner geosynclinal side
- b - axial zone
- c - outer platform side

3 - Platform with Paleozoic (Hercynian) folded basement

4 - Outcrops of folded Paleozoic on ancient surface (Donbass)

5 - Platform with Precambrian crystalline basement

6 - Outcrops of crystalline rocks of the Precambrian on ancient surface (Ukrainian crystalline massif)

7 - Contours of contemporary structure of the Crimean-Caucasian (Indol-Kuban) foredeep by cover of Upper Cretaceous deposits

8 - Contours of basic negative structural elements of the platform region

9 - Contours of component parts of the East Kuban subsidence

10 - Contours of buried subsidences, completely or nearly absent in the structure of the cover of Upper Cretaceous deposits

11 - Extent of the basic positive structural elements of the platform region

12 - Generalized contours on the upper surface of Upper Cretaceous deposits. The disposition of the zones of maximum subsidence of the Crimean-Caucasian foredeep

13 - In the Kimmeridgian-Tithonian (to 2,500 m)

14 - In the Upper Cretaceous (to 2,000 m)

15 - In the Paleocene (to 1,500 m)

16 - In the lower Eocene-middle Eocene (to 700 m)

17 - In the Oligocene-lower Miocene (3,500-4,000 m)

18 - In the middle Miocene-upper Miocene (to 1,600 m)

19 - In the Pontian (500-600 m and more)

20 - In the middle Pliocene-upper Pliocene (to 1,100 m)

21 - Zone of intensive subsidence in the middle Miocene-upper Miocene (1,000-1,500 m), Folding

22 - Geosynclinal type (buried)

23 - Platform type

24 - Transitional type

Circled numbers in map proper (1-26)

ALPINE FOLDED ZONE

1 - Geanticline of the Crimea
2 - Geanticline of the Greater Caucasus
3 - Crimean-Caucasian (Indol-Kuban) foredeep; platform portion of the depression
4 - East Kuban subsidence (A - Vozdvizhensk syncline, B - West Belomechet syncline, C - East Belomechet syncline)
5 - Novocherkassk Upper Cretaceous (Pre-Maastrichtian) subsidence
6 - Yeysk Cretaceous-Paleogene subsidence
7 - Dzhankoy projection
8 - North Sivash projection
9 - Priazov projection (structure of envelope of the Ukrainian crystalline massif)
10 - Southeast extension of the Ukrainian crystalline massif under a Mesozoic-Cenozoic sedimentary cover
11 - Kanev Cretaceous-Paleogene uplift
12 - Berezansk Cretaceous-Paleogene extension
13 - Adyge extension (11, 12, 13 - Kanev-swell)
14 - Kalnibolot prolongation (structure of the envelope of the Ukrainian crystalline massif)
15 - Salsk uplift
16 - Rasshevat extension

STAVROPOL UPLIFT

17 - North Stavropol swell
18 - South Stavropol swell
19 - Rasshevat-Blagodarnensk positive transverse structural complication of the North Stavropol swell
20 - Yegorlyk-Spintsev subsidence
21 - Manych subsidence
22 - Karkinit subsidence
23 - Almin subsidence
24 - Tarkankut swell
25 - Simferopol extension
26 - Mineralnyye vody extension

7) With time the separate portions of the subsidence lost geosynclinal, and then, in places, even transitional traits and gradually all were embraced by a platform regime. This process began and showed itself more completely in the more ancient East Crimean subsidence.

8) Foredeeps have become the locale of the somewhat laterally displaced folding accompanying the development of platforms. These processes have been very active within the boundaries of the Paleocene-Lower Eocene flysch deposition in the Paleogene, which developed on an early phase of formation of the Western Caucasus foredeep and were significant in development of diapir folds in the Oligocene and Neogene, but very inactive in the remaining areas of subsidence.

9) Neither in the Crimea nor the Northwest Caucasus has there been observed an onset of the masses of a folded zone, of whatever degree of significance, against the adjoining foredeep, so widely developed and intensified in other goesynclinal areas (Alpine and Hercynian foredeeps of Western Europe, the pri-Himalayan, the pri-Appalachian and others). Evidently this circumstance conditioned the comparatively weak migration of the East Caucasus and West Caucasus foredeeps in the direction of the platform.

10) The peculiarities of the geotectonic development of various portions of the platform zone of the Azov-Kuban depression have been conditioned in many ways in a perceptible manner in the Mesozoic and Paleogene, but with time have gradually been eclipsed by post-Hercynian movements. These movements, breaking down a zone into a series of subordinate uplifts and subsidences, have appeared on an area in connection with determined inherited tectonic plan and were produced basically by faulting of the basement. Later on, after the interruption of the movements mentioned, the northern platform side of the depression became on the overwhelming portion of its territory a unique monolithic block, within the borders of which only weak local movements were produced.

Summarizing the results of the above analysis, we propose a new tectonic map-scheme of the Azov-Kuban depression (fig. 7). With its compilation we have striven to represent both the peculiarities of the tectonic structure of the depression [31], and the basic laws of its geological development.

With the compilation of the geotectonic peculiarities of the Azov-Kuban depression and the surrounding regions it is possible to see the following: The Karkinit and Alminsk depressions located to the west have subsided comparatively weakly and are of platform type. East of them, beyond the transverse meridional anticlinal bend of the Crimea, is located the Azov-Kuban depression with the intensively sunken Crimean-Caucasian foredeep. The Tersk-Caspian foredeep, separated from the Azov-Kuban depression by the transverse meridional bend of the Caucasus, is still more intensively sunken. The depressions of the Transcaspian, located still further east beyond the Urals-Kopetdag transverse bend, are of platform type. Among them, the further one goes towards the east, the more uplift predominates over subsidence.

Similar correlations are native to the Alpine folded chain located further south. The western part of the Crimea is more weakly sunken than the eastern [16], which is separated from it by the above mentioned transverse uplift. An analagous picture is observed in the Greater Caucasus: the northwestern part is also sunken much more weakly than the southeastern [26], which is located on the other side of the Caucasus meridional uplift. We see, thus, that one and the same law is characteristic in equal degree both for the geosynclinal area and for the belt of submontane subsidences which accompanies it on the north.

Within the borders of the bordering Russian platform the important positive and negative structures nearest to the Alpine zone present themselves analagously. Thus, the Ukrainian crystalline massif, being very stable and firm in its right-bank portion, in the Priazov was affected by Hercynian movements accompanied by subsidence and intrusions. A massif still further east was drawn into subsidence and sunk to a significant depth under the Paleozoic-Mesozoic-Cenozoic cover.

The base of the platform-type Dneiper-Donets depression, located north of the Ukrainian crystalline massif, sinks towards the east, where on the meridian of the Crimean-Caucasian foredeep the depression is transformed into the Hercynian foredeep of the Donbas. Within the borders of the latter in an eastern direction is observed an increase in the thickness of sedimentary deposits; the Donets basin here as a whole is sunken under covers of the Mesozoic-Cenozoic.

The most caved-in portions of the Russian platform are also its eastern regions, oriented in general to the meridian of the Caspian Sea. Here, in particular, is located the deepest of its tectonic depressions – the Pricaspian.

In summary of what has been said above, it is possible to draw the conclusion that within the borders of the southern and southeastern European portion of the U. S. S. R., in equal measure both in geosynclinal and platform-type districts, tectonic activity and the amplitudes of the negative movements taking place are successively increased in a southeastern direction beginning from the meridian of the

Crimea, and attain their maximum in the Caspian meridional subsidence. In the geosynclinal zone and those directly neighboring it, but also sometimes in quite distant platform districts, there is found the often observed distinct transverse zonality established by N. S. Shatskiy [33], reflected in the alternation of important meridional or near-meridional uplifts and subsidences. The basic ovals (the cells of the most active subsidences) are tied to the meridional subsidences in general being regularly strengthened towards the southeast as far as the Caspian transverse subsidence.

REFERENCES

1. Andrusov, N. I., Ocherki istorii razvitiya Kaspiyskogo morya i yego obitateley [OUTLINES OF THE HISTORY OF THE DEVELOPMENT OF THE CASPIAN SEA AND ITS INHABITANTS]: Izv. Imper. russk. geogr. ob-va, t. XXIV, vyp. II, 1888.

2. Arkhangelskiy, A. D., Geologicheskoye stroyeniye i geologicheskaya istoriya SSSR [GEOLOGICAL STRUCTURE AND GEOLOGICAL HISTORY OF THE U.S.S.R.]: Gostoptekhizdat, Moscow-Leningrad, 1941.

3. Beloussov, V. V., Bolshoy Kavkaz [THE GREATER CAUCASUS]: Tr. TsNIGRI, ch. I-III, vyp. 108, 1938; vyp. 121, 1940; vyp. 126, 1939.

4. Beloussov, V. V., Obshchaya geotektonnika [GENERAL GEOTECTONICS]: Gosgeolizdat, Moscow, 1948.

5. Bondarchuk, V. G., Pro tektoniku Prichornomorya [ON THE TECTONICS OF THE BLACK SEA AREA]: Geol. zhur., AN URSR, t. XVII, vyp. 2, 1957.

6. Brod, I. O.; Polster, L. A.; Nesmeyanov, D. B., Geostrukturnoye rayonirovaniye i perspektivy neftegazonosnosti Predkavkazya [GEOSTRUCTURAL ZONING AND PROSPECTS OF GAS AND OIL IN THE CAUCASUS AREA]: suppl. to No. 8, Geologiya nefti (THE GEOLOGY OF OIL): Gostoptekhizdat, Moscow, 1958.

7. Grossgeym, V. A., and others. Tektonicheskoye raionirovaniye Severo-Zapadnogo Kavkaza i Predkavkazya po geologo-geofizicheskim dannym. Tektonika neftenosn. oblastey. [TECTONIC ZONING OF THE NORTHWEST CAUCASUS AND CAUCASUS AREA ON THE BASIS OF GEOLOGICAL DATA. THE TECTONICS OF OIL-BEARING REGIONS]: t. II, Gostoptekhizdat, Moscow, 1958.

8. Dikenshteyn, G. Kh. and others. Geologiya i neftegazonosnost Stepnogo i Predgornogo Kryma [GEOLOGY AND OIL DEPOSITS OF THE STEPPE AND SUBMONTANE CRIMEA]: Gostoptekhizdat, Moscow, 1958.

9. Dubinskiy, A. Ya., Bolshedonbassko-Predkavkazskaya skladchata oblast i epipaleozoiskaya platforma yuga Yevropeyskoy chasti SSSR [THE GREATER DONBAS-SUBMONTANE CAUCASUS FOLDED AREA AND THE EPIPALEOZOIC PLATFORM OF THE SOUTH OF THE EUROPEAN PART OF THE U.S.S.R.]: Geol. stroyen. SSSR [GEOLOGICAL STRUCTURE OF THE U. S. S. R.]: t. III, Gosgeoltekhizdat, Moscow, 1948.

10. Keller, B. M., Verkhnemelovyye otlozheniya Zapadnogo Kavkaza [UPPER CRETACEOUS DEPOSITS OF THE WESTERN CAUCASUS]: Tr. In-ta geol. nauk, AN SSSR, vyp. 48, ser. geol., No. 15, 1947.

11. Korotkov, S. T., Novyye perspektivnyye gazoneftyanyye rayony Krasnodarskogo kraya [NEW PROSPECTIVE GAS-OIL DISTRICTS OF KRASNODARSKIY KRAY]: Geologiya nefti, No. 2, 1957.

12. Kosygin, Yu. A.; Gorlov, S. I., and Karpenko, N. M., Tektonika zapadno predkavkazskogo krayevo progiba [TECTONICS OF THE WESTERN CAUCASUS REGIONAL SUBSIDENCE]: Izv. AN SSSR, ser. geol. No. 4, 1955.

13. Lisitsyn, K. I., K stroyeniyu Doliny R. Manych [TOWARDS THE STRUCTURE OF THE MANYCH RIVER VALLEY]: Transactions of the second international conference of the Association for the Study of the Quaternary Period in Europe, vyp. III, 1933.

14. Mazarovich, A. N., Osnovy geologii SSSR [FUNDAMENTALS OF GEOLOGY OF THE U. S. S. R.]: ONTI, Moscow, 1938.

15. Mazarovich, A. N., Geologicheskoye stroyeniye SSSR [GEOLOGICAL STRUCTURE OF THE U. S. S. R.]: BSE, Soyuz Sov. Sotz. Resp., OGIZ, 1947.

16. Maymin, Z. L., Tretichnyye otlozheniya Kryma [TERTIARY DEPOSITS OF THE CRIMEA]: Gostoptekhizdat, Moscow, 1951.

17. Muratov, M. V., Osnovnye strukturnyye elementy alpiiskoy geosinklinalnoy oblasti yuga SSSR i nekotorykh sopredelnykh stran [BASIC STRUCTURAL ELEMENTS OF THE ALPINE GEOSYNCLINAL

DISTRICT OF THE SOUTH OF THE U. S. S. R. AND CERTAIN CONTIGUOUS COUNTRIES]: Izv. AN SSSR, ser. geol., No. 1, 1946.

18. Muratov, M. V., Tektonika i istoriya razvitiya alpiyskoy geosinklinalnoy oblasti yevropeyskoy chasti SSSR i sopredelnykh stran [TECTONICS AND HISTORY OF THE DEVELOPMENT OF THE ALPINE GEOSYNCLINAL DISTRICT OF THE EUROPEAN U. S. S. R. AND CONTIGUOUS COUNTRIES]: t. II, Izd. AN SSSR, 1949.

19. Muratov, M. V., Tektonicheskaya struktura i istoriya ravninnykh oblastey, otdelyayushchikh russkuyu platformu ot gornykh sooruzheniy kryma i kavkaza [TECTONIC STRUCTURE AND HISTORY OF THE PLAINS AREAS SEPARATING THE RUSSIAN PLATFORM FROM THE MOUNTAINOUS STRUCTURES OF THE CRIMEA AND THE CAUCASUS]: Sov. geol., sb. 48, 1955.

20. Pustilnikov, M. R., O tektonike zapadnogo Predkavkazya [ON THE TECTONICS OF THE WESTERN CAUCASUS AREA]: Sov. geol. sb. 57, 1957.

21. Pukhtinskiy, M. N., Geologiya i gazonosnist zakhidnoi chastin Ukrainskogo Priazovya [GEOLOGY AND GAS DEPOSITS OF THE WESTERN PART OF THE UKRAINIAN PRIAZOV]: Geol. zhurn. AN URSR, t. VIII, vyp. 1, 1941.

22. Rengarten, V. P., Tektonicheskaya kharakteristica skladchatykh oblastey Kavkaza [TECTONIC CHARACTER OF THE FOLDED REGIONS OF THE CAUCASUS]: Tr. III All-Union Congress of Geology, vyp. 2, Tashkent, 1930.

23. Sobolev, D. N., O sredneyevraziyskoy geosinklinali i ob Amadotsiyskom basseyne [ON THE CENTRAL EUROPEAN GEOSYNCLINE AND THE AMADOTSIYSKIY BASIN]: Zap. nauk. doslidn. in-tu geol. pri. Khark. Derzh. Univ., t. V, vyp. 2, 1936.

24. Sobolev, D. N., O tektonike Dnepro-Donetskoy muldy [ON THE TECTONICS OF THE DNEIPR-DONETS SYNCLINE]: Sov. geol., sb. 1, 1941.

25. Sokratov, B. G., O vostochno-Kubanskoy vpadine tsentralnogo Predkavkazya [ON THE EAST KUBAN DEPRESSION OF THE CENTRAL CAUCASUS AREA]: Dokl. AN SSSR, t. 119, No. 6, 1958.

26. Sorskiy, A. A., K istorii geotektonicheskogo razvitiya bolshogo Kavkaza v Yurskoye vremya [TOWARDS A HISTORY OF GEOTECTONIC DEVELOPMENT OF THE GREATER CAUCASUS IN JURASSIC TIME]: Sov., geol., sb. 54, 1956.

27. Uskov, M. V., O tektonicheskoy strukture zapadnogo Predkavkazya [ON THE TECTONIC STRUCTURE OF THE WESTERN PREDKAVKAZYE]: Uch. zap. Rost. gos. un-ta, t. XLVIII, vyp. I, 1957.

28. Khain, V. Ye., Glavneyshiye cherty tektonicheskogo stroyeniya Kavkaza [MAIN TRAITS OF THE TECTONIC STRUCTURE OF THE CAUCASUS]: Sov. geol., sb. 39, 1949.

29. Khain, V. Ye. and Leontyev, L. N., Osnovnyye etapy geotektonicheskogo razvitiya Kavkaza [BASIC STAGES OF THE GEOTECTONIC DEVELOPMENT OF THE CAUCASUS]: Byull. MOIP, otd. geol. t. XXV, No. 3 and 4, 1950.

30. Khain, V. Ye., Neftenosnyye otlozheniya Neogena yuga SSSR i usloviya ikh obrazovaniya [OIL-BEARING DEPOSITS OF THE NEOGENE IN THE SOUTH OF THE U. S. S. R. AND THE CONDITIONS OF THEIR FORMATION]: Izv. AN AzSSR, No. 6, 1951.

31. Chekunov, A. V., Osnovni risi tektonichnoi budovi Azovo-Kubanskoi zapadini [BASIC TRAITS OF THE TECTONIC STRUCTURE OF THE WESTERN AZOV-KUBAN]: Nauk zap. Kiivsk. Derzh. Univ., t. XVI, vyp. XIV, Geol. zbirn, No. 7, 1957.

32. Chekunov, A. V., Geotektonichniy rozvitok Krimsko-Kavkazkogo peredovogo proginu ta deyaki osnovni yogo zakonomirnosti [GEOTECTONIC DEVELOPMENT OF THE CRIMEAN-CAUCASIAN FOREDEEP AND THE BASIC LAWS]: Geol. zhurn. AN URSR, t. XVIII, vip. 1, 1958.

33. Shatskiy, N. S., O glubokikh dislokatsiyakh okhvatyvayushchikh i platformy, i skladchatyye oblasti (Povolzhye i Kavkaz) [ON THE DEEP DISLOCATIONS EMBRACING THE PLATFORMS AND FOLDED REGIONS (VOLGA AREA AND THE CAUCASUS)]: Izv. AN SSSR, ser. geol., No. 5, 1948.

34. Shatskiy, N. S., Meso-Kaynozoyskaya tektonika tsentralnogo Kazakhstana i zapadno-sibirskoy nizmennosti (K voprosu o yavleniyakh unasledovaniya i razvitiya platform) [THE MESO-CENOZOIC TECTONICS OF CENTRAL KAZAKHSTAN AND THE WEST SIBERIAN LOWLAND (TOWARD THE QUESTION OF THE APPEARANCE OF INHERITANCE

AND THE DEVELOPMENT OF PLATFORMS]: Sb. Pamyati akad. A. D. Arkhangelskogo. Izd. AN SSSR, 1951.

35. Shcherik, Ye. A., Tektonicheskoye stroyeniye Prikubanskoy nizmennosti i istoriya eye formirovaniya [THE TECTONIC STRUCTURE OF THE KUBAN LOWLAND AND THE HISTORY OF ITS FORMATION]: Dokl. AN SSSR, t. 94, No. 4, 1954.

36. Shcherik, Ye. A., Nekotoryye paleogeologicheskiye zakonomernosti tretichnogo basseyna na severo-zapadnom Kavkaze [CERTAIN PALEOGEOLOGICAL LAWS OF THE TERTIARY BASIN IN THE NORTHWEST CAUCASUS]: Tr. Akad. neft. prom. SSSR, vyp. III, 1956.

37. Shcherik, Ye. A., Tektonika neftenosnykh oblastey [TECTONICS OF OIL-BEARING REGIONS]: g. Stepnoy Krym, Zapadnoye i Tsentralnoye Predkavkazye Gl.: t. II., Gostoptekhizdat, Moscow, 1958.

38. Yanshin, A. L., Metody izucheniya pogrebennoy skadchatoy struktury na primere vyyasneniya sootnosheniy urala, Tyanshan i mangyshlaka [METHODS OF STUDY OF THE BURIED FOLDED STRUCTURE ON THE EXAMPLE OF THE URALS, THE TIEN-SHAN AND THE MANGYSHLAK]: Izv. AN SSSR, ser. geol., No. 5, 1948.

39. Suess, E., LA FACE DE LA TERRE, Traduit sous la direction de Em. Margerie: v. III, Paris, 1911.

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POTENTIALS FOR PROSPECTING AND EXPLORATION OF BAUXITE ORES AND HIGH-ALUMINA RAW MATERIALS IN THE REGIONS OF CENTRAL ASIA[1]

by

L.P. Konnov

ABSTRACT

The prospects for increased bauxite production in Central Asia is reviewed in the light of recent geologic findings. Characteristic features of the bauxites and other aluminum mineral deposits (alunite, diaspore, etc.) are reviewed, and recommendations made for further exploration and prospecting. For more efficient prospecting and determination of reserves of bauxite ores it is recommended:

1) That exploration of the Carboniferous bauxite deposits in Alaysk-Turkestan region (Chumkartau, Dzhalair Vorukh) be continued.

2) That exploration of the Upper Triassic bauxite deposits (Kairak, Sanjar, Kundzhuaz) be initiated.

3) That the possibilities of bauxite production from a number of Mesozoic deposits (Kansay, Maylisuy, Kshtusk) in the Pskem-Ugam, North Fergana, and Zeravshan regions be investigated.

4) That intensive prospecting efforts be made in rocks of the Carbonfierous (Chumkartau, Dzhalair, East Ferghan), the Triassic (the Gissar Ridge, Darvaz, Pamirs), the Lower Jurassic (the Naryn, Zeravshan and other river basins), and the Lower Cretaceous (the Pskem Ridge).

5) That exploration and prospecting be initiated for other high-alumina ores, (alunite, diaspore, etc.) at certain favorable areas (Gushsay, Kattasay, Karzhansay). --Auth. English Summ.

* * *

Small deposits and shows of bauxite have been exploited in Central Asia since 1932. Most are concentrated within three belts.

1) In the basin of the Ugam and Pskem rivers, from the southwestern portion of the Ugam and Pskem mountain ranges, to the southwestern part of the Chaaktau range in the lower course of the rivers Naryn and Maylis.

2) In the South Fergana on the north slopes of the Alay and Turkestan ranges, including the Malguzar and Chumkartau mountains.

3) In the Zeravshan-Gissar mountain system: on the north slopes of the Zeravshan range and on the south slopes of the Gissar range, and within the southwestern spurs of the latter.

Bauxitic rocks outcrop in Tuarkyre (Western Turkmenia) and in the Eastern Pamirs (Akbaytal). All bauxites in Central Asia are of Paleozoic (Carboniferous), Mesozoic (Lower Jurassic, Upper Triassic, and, possibly, Lower Cretaceous?) age. Two broad types of deposit are recognized: continental (platform-type) and marine (geosynclinal). The first group is contained in eluvial deposits related to lateritic weathering of Paleozoic rocks [3, 7], of which Kundadzhuaz, the Nilyu (Yangoklyk), and the Yary are examples. In this group also are bauxites in Mesozoic continental deposits. Such sedimentary bauxites, formed in lakes, swamps and rivers, are widely distributed in Central Asia. They include the deposits of the Fergana and Gissar districts, (Mayli-Su, Karakiyasay, Kayrak, Sandzhar and others). The second group of bauxites are Carboniferous marine deposits, widely distributed in the southern Fergana. They are concentrated in a narrow belt which stretches east-west for more than 450 kilometers along the northern slopes of the Turkestan and Alay Ranges, from the River Sanzar in the Dzhizak district east to the River Isfayrama in the Kizil-Kiy district, constituting the Fergana bauxite-bearing basin. Here are found the Chumkartau, Malguzar, Dzhalair, Andarak, Kokchetau, Vorukh, Sokh, and Chauvay bauxite deposits.

Let us pass on to a short description of the individual deposits and bauxite districts of Central Asia (see Figure 1).

The Paleozoic group of deposits. Paleozoic bauxite deposits are found only in the southern Fergana, but here they are widely distributed. They occur in limestone at the boundary between the Lower and Middle Carboniferous. They are genetically associated with the southern zone of the Urals-Tienshan geosyncline; while

[1]Translated from Perspektivy poiskov i razvedki boksitovykh rud i vysokoglinozemnogo syr'ya v rayonakh Sredney Azii, Sovetskaya Geologiya, No. 2, 1960, pp. 115-124.

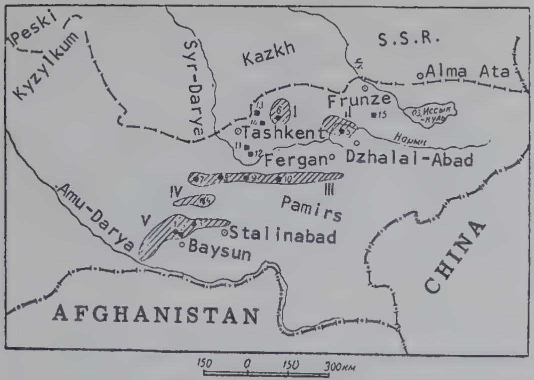

FIGURE 1. Distribution of the most important bauxite deposits in Central Asia, and prospective districts.

Bauxite deposits

1 - Kayrak
2 - Sandzhar
3 - Kundalzhuaz
4 - Kshtusk
5 - Maylisuy
6 - Kansay
7 - Chumkartau
8 - Dzhalair
9 - Kokchetau
10 - Vorukh
11 - Gushay (alunite-diaspore)
12 - Kattasay (alunite-diaspore)
13 - Karzhasay (alunite)
14 - Karankul (alunite)
15 - Sandyk (nepheline rocks)

Bauxite districts

I - Pskem-Ugam
II - North Fergana
III - South Fergana
IV - Zeravshan
V - Gissar (Baysun-Kugitang)

Legend

a - bauxite deposits recommended for detailed survey (1-10)
b - alunite deposits recommended for detailed survey (11-15)
c - districts recommended for intensive prospecting

in the classification of D. V. Nalivkin (1949) they are related to the Fergana type.

Three types of Paleozoic deposits are recognized which are arranged according to probable degree of ore potential: 1) metamorphosed bauxites (emery), 2) bauxite, and 3) bauxitic rocks.

Metamorphosed Bauxites (Emery)

Deposits of metamorphosed bauxites (emery) are represented in the southern Fergana by the Sharaksay deposit, which is not typical for that area. This deposit is located at the western end of the Turkestan range (Malguzar Mountain), where bauxite ores occur as layers, lenses, and pockets in limestone at the boundary between Lower and Upper Carboniferous. The ores range in thickness from several centimeters to 3.7 meters but average 0.3 meters. The overall length of the ore-bearing horizon is about 20 km. Corundum, margarite, calcite, and chloritoids appear as basic ore minerals. Diaspore, rutile, pyrite, magnetite and others also occur occasionally. The content of Al_2O_3 in the ore ranges from 30 to 80 percent; the average content of corundum is between 20 and 30 percent.

According to R. A. Musin [10] the deposits are metamorphic. He regards the emery as the result of recrystallization of bauxite, analogous to the concept of A. F. Sosedko [16].

It should be noted that non-metamorphosed bauxite of industrial grade occurs in the northern part of this same deposit (Kunduk district) in the form of fine lenses and pockets in limestones. West of the Sharadsay deposit there are also fine deposits of emery (in the Nuratau and Tamdytau mountains) which, according to A. F. Sosedko [16], are metamorphosed bauxite.

Assuming that emery and bauxite are related, regions where emery exists should be prospected for bauxite.

Bauxite

Deposits of bauxite are concentrated in the western part of the Fergana basin. The principal deposits of bauxite here are as follows: Chumkartau, Malguzar (Kuduk), Dzhalair, Kyzym-Chak, Andarak and Kokchetau. They are of small extent but rich in alumina. Kokchetau is typical for this group.

The Kokchetau deposit was opened in 1949. (L. P. Konnov and others). The horizon of bauxite and partially bauxitic rock occurs on an eroded karst of Namurian limestone and is conformably overlain by limestones of Middle Carboniferous age. The bauxite horizon ranges in thickness from 0.5 meter to 15 meters; the overall extent is 9 km. The bauxites zones are strongly faulted. The deposit is composed of four sections separated by barren areas: Eastern, Central, Western, and Northern.

The bauxite sequence begins at the base red and brown with bauxite of stony oolitic texture, overlain by pink argillaceous bauxite rock with poorly defined oölitic texture. The bauxites and bauxitic rocks occur as lenses and small irregular bodies. The composition of the bauxite is as follows (in percent): SiO_2, 7.36-12.65; Al_2O_3, 56.20 - 63.10; Fe_2O_3, 8.40 - 15.60; other, 13.60 - 14.68. The rock consists of diaspore, boehmite and kaolinite with admixture of goethite, hydrogoethite and hematite. In view of the small sizes of the ore bodies and the insignificant reserves, the deposit does

not have industrial significance.

Deposits of bauxitic rocks are concentrated in the eastern portion of the Fergana basin. Among these deposits the most important are the Vorukh, the Sokh and the Chauvay.

The Vorukh deposit was opened in 1935 by A. V. Peyve [13, 14]. The bauxite horizon is bedded on an eroded karst limestone surface of the Gaz horizon of the Lower Carboniferous, and is overlain conformably by limestones of the Moscovian stage. The deposit is broken down into three sections. The bauxite horizon extends over 10 km and its thickness ranges from 7 to 30 meters. Only in one section of this deposit (the northern) did we meet with genuine bauxites.

The bauxitic rocks above are of red-brown color with violet tint; below, they are of red-brown color only, greasy to the touch, and friable.

The composition of the bauxite is as follows (in percent): SiO_2, 8.32; Al_2O_3, 51.25; Fe_2O_3, 25.25; other 11.14; and of the bauxitic rocks: SiO_2, 20.74 - 31.02; Al_2O_3, 51.24 - 45.64; Fe_2O_3, 11.65-22.40; other 13.35.

The deposit has been studied only from surface outcrops. In view of the low quality of the bauxitic rocks it has no industrial significance at the present time. Potentially it might provide supplemental supplies of raw material for aluminum in conjunction with other deposits of high-quality bauxites.

Practically all the remaining bauxite deposits and shows of the Paleozoic group are analogous to the ones described above. The Chauvay group of ore shows, located in the extreme east part of the area is somewhat exceptional; here the bauxite band consists of four layers of bauxite rocks. The thickness of this band ranges from 22.5 to 46 meters.

Available geological information [12] permits us to assume that the eastern Paleozoic bauxite-ore zone, just like the western, does not end in the district of Chauvay, but continues farther east, to the periphery of the Terek-Davan (Alay Range). The western border coincides with the belt of distribution of emery deposits and is conditionally drawn in the district of Tamdytau.

All known Paleozoic bauxites of Central Asia, are typical sedimentary marine deposits [1, 2]. However, in the west, in the mountain system of Manguzar [10], Nur-Ata and Tamdytau [16], are metamorphosed bauxites (emery), evidence of intensive metamorphism in these regions.

Study of the Fergana bauxite basin indicates uneven distribution of Carboniferous bauxite deposits. The eastern part of this basin contains large deposits (Vorukh, Sokh) of non-commercial grade ores (bauxitic rocks). In the western part of the basin only small deposits of bauxite (Kokchetau, Kyzyl-Chak, Chumkartau and others) are known; they contain meager, but high-grade reserves. Larger deposits of bauxite can be found at a different stratigraphic horizon trending towards the border portion of the basin. However, this prospective district is within the wide Fergana depression and can be investigated only by drilling, which in most cases is impossible.

In the western part of the Fergana basin, detailed prospecting should be conducted in and near the Chumkartau, Dzalair, Kokchetau and Vorukh regions, for shows of bauxite ores at greater depths. In the eastern part geological-prospecting for new Carboniferous bauxite deposits must continue in the Abshir and Aravan regions. No bauxites have yet been discovered in Silurian and Devonian sediments of Western Asia.

On the surface, Carboniferous high-quality bauxites are strongly ruptured, and partially displaced by strong thrust faults; therefore their principal beds may occur at depth. Considering the regional distribution of bauxites within the borders of northern foothills of the Turkestan and Alay ranges, and the superficial knowledge of the deposits, one may assume that beds of commercial bauxite ore can be found at a depth. Hence, exploratory drilling in these regions is recommended.

Mesozoic Deposits

Deposits of this group play a major role in the bauxite reserves of Central Asia. They are concentrated in the three above-mentioned ore districts, with the Baysun (or Gissar) district in first place, the Fergana in second. Some 90 deposits of bauxites or bauxitic rocks are known in the Mesozoic of Central Asia.

Most of the bauxite deposits of undetermined industrial importance belong to the Triassic and are associated exclusively with platform-type continental sediments. This may be explained either by the lack of survey data on Mesozoic deposits or by the possibility of their having been eroded away.

The various bauxite deposits of this group should be re-evaluated in the light of weathering of outcrops.

It should be taken into consideration that the Paleozoic-Mesozoic contacts, which are barren on the surface, may contain commercial bauxites at depth. Since the relief of the Paleozoic-Mesozoic surface is apparently uneven, the bauxites may be thickest in depressions on this surface. Drilling, although practical in several instances, has not yet been conducted for Mesozoic bauxite deposits. Exploratory tunnels have been driven only for short distances, often not

beyond the weathering zone.

Brief summaries of the Mesozoic bauxite deposits are given below.

The Baysun deposits (in the southwestern spurs of the Gissar Range) possess the highest content of alumina. They are associated with an Upper Triassic bauxite-bearing formation [4] of the Angara type [15], sporadically distributed, filling depressions in the Paleozoic relief. This explains the great variations in their thickness. The bauxites are developed in 64 comparatively small districts and occur between the Lower Jurassic conglomerates and sandstones, bedded directly on the Paleozoic. At the Sandzhar, Kayrak deposits in the Kugitangtau mountains have been found plant fossils which, according to M. I. Brik and T. A. Sikstel [6, 8], are of Upper Triassic age. Outcrops of bauxite-bearing sediments of previously undetermined age in the southwestern Gissar range belong, apparently, to the Rhaetian series.

Let us examine, for example, the largest – the Kayrak bauxite deposit. It is located near the watershed of the Baysuntau Mountains at an elevation of 3,000 meters. It was discovered in 1940 by L. P. Konnov and Ya. K Pisarchik and partly surveyed in 1941 and 1948. There are two separate sheet-type bauxite beds, up to 5 meters thick; and 2.20 km in length.

Both beds consist of from two to five layers, differing in pigment, structure, and chemical composition. Three are bodies of commercial bauxite, of lenticular form, up to 2.8 meters thick and up to 350 meters long. Macroscopically the bauxites are of dark-gray (and other shades) of oölitic rocks. They are bedded usually in the lower portion of the bauxite-bearing beds. The chemical composition of the bauxites is as follows (in percent): SiO_2, 8.80 to 11.32; Al_2O_3, 46.54 to 45.68; Fe_2O_3, 3.17 to 10.77; FeO, 17.52 to 22.97; other 10.0 to 10.83.

Tests of the Kayrak bauxites (VAMI, 1944) have shown that the extraction is profitable from either bauxite or from a 1:1 mixture of bauxites with bauxitic rocks. The deposit has practical value, but is most unfavorably located. Intensive survey of this deposit is necessary.

The Sandzhar, Kundadzhua and adjacent bauxite deposits, also have prospecting potential in view of their extent and likely reserves.

The Fergana deposits located in the south and southeastern Fergana include the Karakiyasay and the Maylisuy deposits.

The Karakiyasay deposit is represented by small lenses of bauxites and bauxitic rocks lying in karst hollows of Upper Silurian limestones, and redeposited in Upper Triassic sediments as bauxite breccia. The chemical composition of the bauxites is (in percent): SiO_2, 3.5 to 12.5; Al_2O_3, 52 to 69; Fe_2O_3, 12.5 to 20.6; other, 12.78 to 14.06. The bauxite breccia contains much (24 percent) silica and is not of commercial grade.

The Maylisuy deposit was discovered in 1935 by A. V. Payve [13]. The bauxite-bearing band overlies the uneven relief of Lower Carboniferous limestones and constitutes the basal sediments of the overlying Jurassic. It is developed in an area 800 by 200 meters. Thickness of the band ranges from 7 to 12 meters, the thickness of the bauxite lens from 1.5 to 2.5 meters. The bauxite-bearing band, judging from its bedding on coal-bearing layers, is no younger than Liassic. The chemical composition of the bauxite is as follows (in percent): SiO_2, 7.76 to 17.68; Al_2O_3, 26.15 to 44.86; Fe_2O_3, 29.20 to 37.20; others 16.44 to 24.12. It is a typical lacustrine deposit. Further surveying is necessary for a determination of reserves.

In the Pskem range a number of outcrops of Mesozoic bauxites have been mapped. Among these is the Kansay outcrop, which is Cretaceous according to preliminary data. It consists of small lenses of bauxites and bauxitic rocks which fill the irregularities of an ancient relief on Carboniferous limestones. The chemical composition of the bauxite is as follows (in percent): SiO_2, 3.6; Al_2O_3, 44: Fe_2O_3, 20.3; other, 27.1. This bauxite outcrop requires additional investigation.

Central Asia can be divided into promising and unpromising regions, based on geological structure and pattern of distribution of bauxite deposits.

Among the promising are the regions of Mesozoic continental sedimentation, including the Ugam, Naryn, Lyailyak (South Fergana) and Zeravshan (Kshtut) river basins, and the southwestern spurs of the Gissar range.

According to preliminary survey data on the Maylisuy, Karakiyasay and Kundadzhua bauxite deposits, it can be assumed that none is by itself of industrial value. However, the Kayrak deposit, which needs more study, is not to be excluded.

Detailed geological mapping in conjunction with geophysical exploration of bauxite reserves must be conducted in the following districts: Kyzyltal (Kansay), Maylisu and Kshtut-Kundadzhuaz.

Since the bauxites of Central Asia usually possess magnetic properties, geophysical methods of investigation (ground magnetic survey, magnetic prospecting, electrical survey, and others) can be utilized with success.

Further prospecting of Mesozoic bauxites

might be directed toward Cretaceous sediments, toward search for bauxites in the new regions of Central Asia (the northeastern Kyzyl-Kum).

Kaolin And High-Alumina Raw Materials (alunite, diaspore, nepheline).

In regards to the appearance of such types of aluminum ores as alunite, diaspore, kaolinite, in several districts of Central Asia (Uzbekistan, Tadzhikistan) in conjunction with the zones of hydrothermal alterations of rocks (quartz-sericite formation), great attention ought to be directed toward prospecting such deposits in similar districts of other of Central Asian republics. Particular attention is due the presence in Jurassic and other sediments of alumina-rich kaolin and extrusive (nepheline), from which the extraction oxides or electrothermal extraction (silicon-aluminum alloys) is feasible. Sandyk [16] is one such deposit.

A short description follows of the alunite-diaspore shows concentrated mainly in the Angren and Chatkal regions of the Western Tien-Shan. They have been partly investigated by S. Ye. Pryanishinkovy and other geologists.

In the Angren district leached and silicified secondary quartzites are fairly widely developed, being developed at the expense of Upper Paleozoic effusives and showing themselves as plagioclase porphyrites, dacite porphyrites, and tuff. Large accumulations of high-alumina minerals (alunite, diaspore, corundum, kaolinite, pyrophyllite, serpicite, and others) are among the leached rocks.

The leached rocks are in the form of belts lying almost east-west or as spots, when they are related to fracture zones or to tectonically weakened zones. The largest zone of leached rocks, several kilometers wide and 20 kilometers long, stretches from Saukbulak to Kendyrsay. Several districts with alunite-diaspore ores (Gushsay, Kattasay, Urgaz, Shaugaz, Pisteli, Kyrkyrsay, Ab'yazsay and Dzhakkobau) are within this belt.

The first three of these are the largest. However, their potential has still not yet been established.

The alunite ores have a macrocrystalline structure, which distinguishes them from similar ores of the Zaglik deposit. The average content of alunite in the rock is from 45 to 80 percent. These ores have industrial potential. They must be surveyed to determine deposit structures, distribution at depth and reserves.

In this same region, within the boundaries of a brown coal deposit also named Zaglik, is found a group of kaolin clay deposits (Appartak, Dzhigiristan and Chushkabulak). These deposits have been studied by D. M. Bogdanovich and N. P. Petrovya. The kaolin clays have been found on an area of more than 1,500 km^2, averaging 40 meters thick. In the productive clay series are found these intercalated forms of clay: white kaolins, colored kaolins, and gray clays. The chemical composition of the enriched kaolin is (in percent): SiO_2, 47.5; Al_2O_3, 34; MgO, 0.80; others, 13.

Laboratory tests (VAMI, 1950) have established that the Angren kaolins are suitable for aluminum production by either sintering with limestone or the hydrochloric acid method, with yield of up to 93 percent alumina. The prospected reserves of kaolin clays are remarkable.

Coal is extracted from the Angren deposit by the open-pit method, whereby the kaolin is dumped. This kaolin dump can guarantee the raw material for a large aluminum plant.

In the Chatkal district only the Aktash deposit has been prospected and found to contain an important complex of ores: andalusite, alunite, dumortierite, diaspore, corundum, pyrophyllite and kaolinite. The most important industrially are the alunite and diasporite ores.

The following other deposits in this region can be noted: Kurgazsay, Terekli-Ziman, Aksagatin (alunite-diaspore), Karzhansay (alunite) and Karankul (alunite). The latter three with an alunite content of from 30 to 60 percent have the best potential.

In conclusion we note that the expedient execution of further survey and prospecting efforts with the purpose of ascertaining alumina-rich ore minerals is bound up with "secondary quartzites." Particular attention must be paid to complex prospecting in such rocks.

CONCLUSIONS

1) Until 1922 it was believed that bauxite deposits did not exist in Central Asia. Subsequently a series of industrially important bauxite districts and deposits were discovered here.

2) Two cycles of bauxite-formation have been established for Central Asia: the Paleozoic (Carboniferous) and the Mesozoic (Triassic-Jurassic). The first of these precedes the peak of the Middle Carboniferous transgression, while the second is the result of pre-Liassic erosion and deposition.

3) The bauxite deposits and shows are of various types - marine, lacustrine, fluvial, eluvial and lateritic, of which those of the Upper Triassic (Kayrak, Kunda-Dzhuaz) undoubtedly will have industrial value.

4) First-class geophysical and geological surveys on the Mesozoic group of bauxite deposits-Kayrak, Sandzhar, and Kunda-Dzhuaz-

are needed to resolve the bauxite ore question in Western Asia. Tests of bauxite enrichment must also be conducted on these deposits.

Of somewhat less interest, but still significant, are the Dazhlair, Kokchetau and Vorukh Paleozoic bauxite deposits in the western part of the Fergana bauxite basin) where exploratory drilling is necessary to further refine geophysical and other prospecting.

The search for new deposits can be carried out on a broad scale in promising and covered areas of the Carboniferous (Chumkartau and eastern Fergana), Triassic (the southwestern spurs of the Gissar Range, the Darvaz and the Pamirs), Lower Jurassic (Naryn and Zeravshan river basins), and, possibly, Lower Cretaceous (Pskem Range).

In addition to the bauxite deposits, important deposits of high-alumina raw material (alunite, diaspore, etc.) are found in Central Asia mostly in the Angren and Chatkal districts, where careful prospecting of the Gushsay, Kattasay and Karzhansay deposits also is necessary.

5) The growth of bauxite ore resources undoubtedly lies through more widespread prospecting and surveying, and it may solve the problem of creating a materials base for the aluminum industry in the southeastern U. S. S. R.

REFERENCES

1. Arkhangelskiy, A. D., K voprosu ob usloviyakh obrazovaniya boksitov v SSSR [TOWARDS THE QUESTION OF THE CONDITIONS OF FORMATION OF BAUXITES IN THE U. S. S. R.]: Byull. MOIP. v. 9, no. 4, 1933.

2. Arkhangelskiy, A. D. Typy boksitovykh mestorozhdeniy SSSR i ikh genezis [TYPES OF BAUXITE DEPOSITS OF THE USSR AND THEIR GENESIS]: from the book Trudy Konferentsii po Genezisu Rud Zheleza, Margantsa i Alyuminiya, [WORKS OF THE CONFERENCE ON THE GENESIS OF IRON, MANGANESE AND ALUMINUM ORES]: Moxcow-Leningrad, 1937.

3. Vikulova, M. F. Teoreticheskiye osnovy poiskov boiskov boksitov na territorii SSSR" [THEORETICAL BASES OF THE SEARCHES FOR BAUXITES ON THE TERRITORY OF THE U. S. S. R.]: Mat. VSEGEI, Ser. polezn. iskop., no. 3, 1946.

4. Konnov, L. P. K voprosu o metamorphizme verkhnetriasovoy gumidno-kontinentalnoy formatsii Gissarskogo Khrebta [TOWARDS THE QUESTION OF THE METAMORPHISM OF THE UPPER TRIASSIC HUMID-CONTINENTAL FORMATION OF THE GISSAR RANGE]: Zap. Uzbek. mineral. ob-va, no. 10, AN UzSSR, 1956.

5. Konnov, L. P., Nekotoryye dannyye o Sovremennom Vyvetrivanii Mezozoiskikh Gumidno-kontinental'nykh boksitovykh porod [CERTAIN DATA ON THE RECENT WEATHERING OF MESOZOIC HUMID-CONTINENTAL BAUXITIC ROCKS]: Zap. Uzbek. mineral. ob-va, no. 10, AN UzSSR, 1956.

6. Konnov, L. P. Lithologicheskiy ocherk verkhnetriasovyykh boksitonosnykh otlozheniy v Yuzhnom Uzbekistane [LITHOLOGICAL OUTLINE OF THE UPPER TRIASSIC BAUXITE DEPOSITS IN SOUTHERN UZBEKISTAN]: Izv. AN UzSSR, Ser. geol. no. 2, 1957.

7. Konnov, L. P. K voprosu o boksitakh Kundadzhuazskogo mestorozh-deniya v Yuzhnom Uzbekistane [TOWARDS THE QUESTION OF THE BAUXITES OF THE KUNDADZHUAZ DEPOSIT IN SOUTHERN UZBEKISTAN]: Dokl. AN UzSSR, no. 4, 1957.

8. Konnov, L. P. O granitse Triasa i Yury v Yugo-Zapadnykh ostrogakh Gissarskogo Khrebta [ON THE BOUNDARY OF THE TRIASSIC AND THE JURASSIC IN THE SOUTH-WESTERN SPURS OF THE GISSAR RANGE]: AN UzSSR, no. 4, 1958.

9. Konnov, L. P. Mezozoiskiye boksity Sredney Azii [THE MESOZOIC BAUXITES OF CENTRAL ASIA]: from the book Boksity, ikh mineralogiya i genezis [BAUXITES, THEIR MINERALOGY AND GENESIS]: Izd. AN SSSR, 1958.

10. Musin, R. A. Nazhdaki Malguzarskikh gor i nekotoryye voprosy obrazovaniya i nakopleniya svobodnogo glinozema [EMERY OF THE MALGUZAR MOUNTAINS AND CERTAIN QUESTIONS ON THE FORMATION AND ACCUMULATION OF FREE ALUMINA]: Zap. Uzbek, otdel. Vsesoyuzn. mineral. ob-va, no. 8, 1955.

11. Nalivkin, D. V. Ocherk geologii Turkestana [OUTLINE OF THE GEOLOGY OF TURKESTAN]: Tashkent, 1926.

12. Nalivkin, D. V. Paleogeografiya Sredney Azii v Paleozoya [PALEOGEOGRAPHY OF CENTRAL ASIA IN THE PALEOZOIC]: Tr. Vsesoyuzn. syezda geologov v. 1928 g, no. 2, 1928.

13. Peyve, A. V. Boksity Sredney Azii [BAUXITES OF CENTRAL ASIA]: TPE AN SSSR, no. 99, 1937.

14. Peyve, A. V. Problema poiskov boksitov v

Tyan-Shan [PROBLEM OF SEARCHES FOR BAUXITES IN THE TIEN-SHAN]: Tr. TPE [Transactions TPE for 1935], za 1935g., 1937.

15. Popov, V. I. Sostoyaniye i zadachi izucheniya osadochnykh formatsiy [NATURE AND TASKS OF THE STUDY OF SEDIMENTARY FORMATIONS]: Dokl. Soveshch. po osadochnym porodam, no. 1, AN SSSR, Moscow, 1952

16. Sosedko, A. F. Nazhdaki i boksity Sredney Azii [EMERY AND BAUXITES OF CENTRAL ASIA]: Zhurnal SONAT, no. 11-12, Tashkent, 1939.

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STRATIGRAPHIC AND CORRELATIVE SIGNIFICANCE OF TERRIGENOUS COMPONENTS OF SEDIMENTARY ROCKS[1]

by

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REVIEWER'S NOTES

This article contains some basic ideas on the origin of detrital minerals from weathered and non-weathered zones. Implications relative to the interpretations of sedimentary petrography and to studies of recent sediments should be brought to attention of geologists in general.

ABSTRACT

The widely applied method of stratigraphic division of sediments and their correlation on the base of terrigenous components developed by Illing, Baturin and others, was based on the fact that the composition of the sedimentary terrigenous components depends upon the petrographic composition of the distributive province rocks. The author, using terrigenous components for stratigraphic purposes, has based his method of the influence of the ancient crusts of weathering upon their composition. Under the ancient kaolin-type weathering conditions the mineralogy of forming sediments was very uniform: among rock-building minerals prevailed quartz, kaolin, partly hydromicas. Among accessories the following stable minerals prevailed: ilmenite, leucoxene, chromite, zircon, rutile, disthen, staurolite, tourmaline, cassiterite, and also less widely spread minerals such as sillimanite, anatase, brucite, corundum, xenotime, columbite, monazite, topaz, spinel, andalusite, diamond, gold, platinum, osmiridium.

Unstable under the ancient kaolin weathering conditions were: garnets, pyroxenes, amphiboles, epidote, magnetite, apatite, sphene, serpentine, olivine, titano-magnetite. Their contents in the deposits, formed at the expense of the kaolin crust of weathering, were as a rule insignificant.

From the above it is clear that the ancient weathering could have affected the mineralogical composition of accessory minerals of deposits, even much stronger than the petrographical composition of the distributive province.

In the course of geological times the total balance of stable accessory minerals, able to undergo repeated weathering and erosion, has the tendency to grow in spite of their dilution in sediments during certain epochs.

The author tried to give a stratigraphic division of the Mesozoic and Cenozoic deposits in the South Urals from terrigenous components.

This method can find a wide application.

In the future it will be advisable to combine the above mentioned method with the method of Illing and Baturin and others, taking into account the petrographic influence of the rocks of the distributive province.--Auth. English summ.

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The standard procedure of mineralogical studies is to tie up the composition of terrigenous minerals in sedimentary rocks with the possible source rocks. In so doing, however, some students are prone to forget the possible development of a weathering crust — a fact which often leads to erroneous conclusions.

Interesting in this respect is the Mackie work [14] which ties up the relative content of weathered and fresh feldspars in a deposit with climatic changes in the course of several geologic epochs. V.P. Baturin takes up the same subject in his works, where he states that "a group of stable minerals is especially characteristic of ancient deposits" [2, p. 30] and that "the method of analysis of climates of geologic past may turn out to be very valuable" [3, p. 213].

Special features of sedimentation under the condition of formation of a kaolin weathering crust. The profile of ancient weathering crusts may be very variable. Turning to the present day climatic zones, we note that the so-called lateritic profile with its sizable accumulation

[1] Translated from Sovietskaya Geologiya, 1960, no. 3, p. 28-39. Russian footnote to title reads, "Presented at the XXI International Geological Congress and recommended for publication by the National Committee of Geologists of the Soviet Union" however, no record of this is evident from the Program, Volume of Abstracts, or Parts I-XXII of the published reports of the congress.

of free alumina in the weathering crust is known only from the tropics. In changing from the tropical to sub-tropical conditions, alumina laterites disappear, being replaced — going north — consecutively by kaolin, hydromicaceous-kaolin, and hydromicaceous clays [4]. Still farther north, physical weathering becomes the predominant factor.

Of especial importance in the past history of the present day temperate provinces was the kaolin profile weathering crust which has left a distinct impression on the lithology of ancient continental deposits. We shall consider this phenomenon in more detail.

It is well-known that in kaolin weathering, all rock-forming minerals, save quartz, are almost completely decomposed, with various chemical compounds leached out of the eluvium in aqueous solution. Thus, all rocks, except for vein quartz, quartzite, and some siliceous varieties, are fully altered and changed for the most part to a clay mass, chiefly kaolin.

Let us now consider the formation of sediments under conditions responsible for the formation of such a weathering crust. We assume for simplicity that the source area is made solely of granites with a series of quartz veins. The granite weathering crust is represented by kaolin clay with grains of primary quartz. The quartz veins have undergone disintegration through fracturing. It appears, then, that the following material enters the erosion zone: vein quartz, chiefly in large fragments which eventually give rise to pebble beds; quartz grains, deposited as sand beds; and finally fine kaolinite scales forming kaolin clays. Formed as a result of erosion of this weathering crust and the deposition of its produce would be a body of sediments consisting of quartz pebble, quartz sand, and kaolin clay.

In reality, the composition of the source rocks may be more diversified. This, however, does not alter the substance of the process. Thus in the presence of quartzites and siliceous rocks in the source area, pebble, gravel, and sand will be formed at the expense of these rocks, but alumosilicate rocks and rock-forming minerals will be missing among the fragments.[2]

On the whole, the lithology of sediments under conditions favorable for the development of kaolin weathering crust is very monotonous and consistent: kaolinite predominates among clay minerals; hydromicas are present; the psephitic and psammitic fractions are made up almost exclusively of fragments and grains of quartz, quartzite, and siliceous rocks.

[2]In fact, however small amounts of them are present because of an incomplete decomposition of primary minerals in the weathering crust.

Minerals resistant and non-resistant to ancient weathering. A study of psephites and psammites in the above-described sediments shows that such heavy minerals widely developed in source rocks, as garnets, pyroxenes, amphiboles, epidote, and magnetite occur in sediments in very small amounts or else are altogether missing. This means that such minerals were unstable during the ancient weathering. Among such minerals are also apatite, sphene, serpentine, olivine, titanomagnetite, and zoicite.

Belonging to another group of minerals whose concentration in deposits related to the erosion of ancient weathering crusts is considerable are ilmenite, leucoxene, chromite, zircon, rutile, disthene, staurolite, tourmaline, cassiterite, and such less common minerals as sillimanite, octahedrite, brookite, corundum, xenotime, columbite, monazite, topaz, spinel, andalusite, diamond, gold, platinum, and osmium-iridium. These minerals were relatively stable during the kaolin-type weathering.

A direct study of the constitution of the heavy fraction of an ancient weathering crust of metamorphic schists, granites, and other rocks reveals an extremely motley picture, depending on the composition of the source rock and the degree of its weathering. The following composition has been established for strongly kaolinitized rocks, altered to primary kaolins: a) stable minerals, 82%; b) unstable minerals, 3.9%; c) authigenic minerals, 14.1%. Present among stable minerals are ilmenite, 43%; staurolite, 18%; rutile, 6.9%; tourmaline, 3.8%; zircon, 3.2%; leucoxene, 3%; disthene, 2.3%; others (chromite, monazite, xenotime, spinel), 1.8%. Foremost among the unstable minerals is epidote (1.5%), with others present in fractions of a per cent (magnetite, apatite, garnet, amphiboles, sphene). These data have been corroborated by the results of a correlation of the average of heavy minerals in the South Urals source rocks and in Upper Oligocene deposits formed from the erosion of their weathering crust (Table 1).

Concentration, impoverishment, and inheritance of heavy minerals in sediments. According to the data of Table 1, the concentration of stable heavy minerals in Upper Oligocene sediments of the South Urals is at least eight times greater than that in the source rocks.

In a number of instances, sediments enriched in stable heavy minerals occupy large areas; they appear to have been formed in the erosion of a thick weathering crust in source outcrops. Some of these instances are Middle Oligocene deposits of the Trans-Ural region; Poltavian and Sarmatian titaniferous deposits of the Dnieper region; littoral placers of Australia, India, and Brazil, etc. In many instances, we apparently deal with a secular "growing balance" of stable

Table 1

Minerals	Average content, kg/m^3	
	In source rocks	In Upper Oligocene deposits
Unstable		
Magnetite	13.4	0.36
Sphene	0.59	0.001
Epidote group	7.5	0.78
Stable		
Ilmenite	1.98	9.8
Leucoxene	0.09	1.83
Chromite	0.09	1.07
Zircon	0.21	1.57
Rutile	0.18	1.07
Disthene	0.115	1.88
Staurolite	0.11	4.2
Tourmaline	0.22	0.78

accessory minerals, accumulated in the course of many geologic epochs.

Under certain conditions, of which more will be said, there is a decrease in the content of heavy stable minerals in sediments, occurring parallel with their enrichment in minerals non-resistant to weathering. In this process, the over-all balance of heavy minerals is not changed substantially. In being superimposed on "impoverished" deposits of a new weathering crust, the unstable accessory minerals were destroyed, thus creating conditions favorable for a new enrichment in stable minerals, in their current erosion.

Thus, while unstable minerals enriching the sediments in certain geologic epochs and under conditions may be destroyed in a weathering zone under certain climatic conditions, the stable minerals may be inherited by a body of sediments, from very ancient geologic epochs.

Factors determining the concentration of stable terrigenous components in sediments. The development of a kaolin weathering crust and the accumulation of stable accessory minerals in sediments were promoted by a humid and warm climate and a comparative tectonic quiescence. The first of these factors brought about the formation of a suitable weathering profile, while the second created an environment favorable for the development of a weathering crust.

Small positive tectonic movements in the presence of a sufficiently thick weathering crust may not have affected the concentration of stable accessory minerals in sediments, because the shallow incision of a river system caused by them may not have reached unweathered rocks below the crust. Strong tectonic movements, on the other hand, sharply modified the sediment composition to a polymictic one, with minerals non-resistant to weathering predominant among the accessory. Such minerals could be involved into sedimentation also during a slow land subsidence, accompanied by a marine transgression and a more or less deep abrasion.

Heavy minerals from extrusive and metamorphic rocks and from a weathering crust. R. Reyborn and G. Milner, V.P. Baturin, and other authors present rosters of accessory minerals from various extrusive and metamorphic rocks. Specifically, according to V.P. Baturin, typical of granitoids are zircon, biotite, sphene apatite; of basic to intermediate effusives — pyroxenes and amphiboles; of ultrabasics — pyroxenes, spinel, and chromite; and for metamorphics — disthene, staurolite, sillimanite, and garnet. Of course, these minerals may be regarded typical of their corresponding rocks under ideal conditions only. Under natural conditions, and because of the effect of a number of factors (assimilation, injection, etc.) considerable complications in the mineral composition are possible. The content of principal heavy accessory minerals in principal rock groups of the South Urals, as revealed by the study of artificial concentrates is given in Table 2.

Should a weathering crust be superimposed on these rocks, with only the stable minerals preserved in it, the difference in mineral associations of different rock groups would not be as distinct. By the same taken, the petrographic composition of a source province cannot be reconstructed from sediments formed in the erosion of a kaolin weathering crust; such a weathering may have a stronger effect on the composition of the sediments' accessory minerals.

Composition of accessory minerals as a function of paleogeographic conditions. It is clear from the above exposition that the composition of accessory minerals in a sedimentary body is in direct relationship not only to the petrographic composition of the source province but to its tectonic and climatic conditions.

Designating by M the stable mineral group and Q the unstable, a table can be compiled to illustrate the predominant character of accessory minerals arriving at a sedimentary body under different paleogeographic conditions (Table 3).

Paleogeographic factor. It follows from the above exposition that ratio of stable (M) to unstable (Q) mineral groups is determined directly by paleogeographic conditions of sedimentation. We have named this ratio $K = M/Q$, the paleogeographic factor [13].

For modern tropical and sub-tropical placers (Australia, India, Brazil), as well as ancient sequences formed in the erosion of a weathering crust (Mediterranean titanium deposits,

Table 2

Minerals	In kg/m3 Granitoids	Gabbros	Serpentinites	Basic to intermediate effusives	Metaschists	Average
Ilmenite and leucoxene	1.9	9.2	0.01	2.2	0.71	2.07
Chromite	0.05	1	—	0.04	0.04	0.09
Zircon	0.4	0.03	0.01	0.05	0.05	0.21
Rutile	0.2	0.01	0.01	0.3	0.04	0.18
Monazite	0.01	—	0.01	—	0.0005	0.005
Disthene	0.1	1	—	0.02	0.1	0.115
Staurolite	0.08	0.9	0.01	—	0.13	0.11
Tourmaline	0.4	0.26	0.01	0.02	0.1	0.22
Unstable						
Magnetite	6.2	68.5	76.0	19.4	5.1	13.4
Apatite	1.4	1.3	—	0.9	1.1	0.96
Sphene	0.75	—	—	0.7	0.25	0.59
Garnet	0.6	0.03	0.02	4.8	0.33	1.76
Epidote	4.5	17	0.4	15	1.7	7.5
Amphiboles	2.3	30	0.01	12.2	1.7	6.2
Pyroxenes	0.2	15.2	—	29.8	0.05	9.5
All others	8.6	38.6	1.4	11.6	10.1	12.09
Total heavy fraction	28.5	173	77.9	97	21.5	55
Number of analyses	66	7	1	11	33	151

Table 3

Main factors		Tectonics: Relative quiescence	Minor uplifts	Subsidence: Without sea transgression	Subsidence: With sea transgression	Considerable uplifts (or shifts)
Climate	Temperate to cold	Q + M	Q + M	Q + M	Q + M	Q + M
	Warm to humid	M	M (at times Q + M)	M	Q + M	Q + M

Borovichi-Lyubytin clay deposits), factor K is large as shown in Table 4 compiled from data in papers by M. A. Malyshev [7] and M. F. Vikulova [5].

When a weathering crust is missing and the erosion affects comparatively fresh outcrops, the paleogeographic factor drops down to one and even less, of which more will be said below.

Stratigraphy of Mesozoic and Cenozoic deposits in the South Urals, inferred from terrigenous components. This author has studied deposits on the east slope of the South Urals (including adjacent area of the West Siberian plain). Along with standard concentrates obtained by washing unconsolidated rocks, he used a few artificial concentrates obtained by crushing massive rocks, with a subsequent washing of material. Methods of sampling were different in different instances, because concentrates had been taken for a number of years and for different purposes. The sampling was done by the furrow method, quartation of unconsolidated material obtained from hand-drilled boreholes, pick sampling from mining dumps, but mostly from lump ores. The samples were washed in a pail, up to a "gray concentrate" stage (with control sampling of washed-out sandy material) or else on special Willfley tables. The volume (or weight) of washed material was measured beforehand.

The concentrates were analyzed in the laboratory of the Uralian Geological Administration (A. V. Fadeyeva, Director). Their quantitative mineral content was determined visually and approximately; per cent by weight was determined for industrially valuable material. The results were converted for the heavy fraction as a whole, with its content in a cubic meter of rock.

The area under study comprised parts of the basins of rivers Tobol, Mias, and Uy, of the Ob system. Developed in the west of it are Paleozoic and probably pre-Paleozoic folded structures formed by sedimentary, effusive, and metamorphic rocks cut by granitoids, gabbroids, and ultrabasics of the Hercynian and Caledonian tectono-igneous cycles. Related to Lower

Table 4

Minerals	Content, %					
	Australia	India	Brazil	Middle-Dnieper titanium deposits	Borovichi-Lyubytin deposits	
					brittle clays	plastic clays
Ilmenite and leucoxene	26.5	65	55	40.4	—	—
Rutile	30.2	—	5	13.5	4.2	1.8
Zircon	38.8	8	25	13.5	25	14
Monazite	0.5	2	5	Trace	—	—
Tourmaline	—	—	Trace	3	17	8
Staurolite	—	—	Trace	15	0.3	—
Sillimanite	—	10	Trace	11.2	—	—
Disthene	—	—	Trace	3.4	5.2	2
Corundum	—	—	Trace	Trace	—	—
Spinel	—	—	Trace	Trace	—	—
Andalusite	—	—	—	Trace	—	—
Octahedrite	—	—	—	Trace	—	—
Ore minerals (w/o magnetite)	~2	—	—	—	48.3	73.8
Garnet	~2	15	—	—	—	—
Pyroxenes	—	—	—	—	—	0.4
Paleogeographic factor	49	5.7	∞	∞	∞	250

Mesozoic fault zones in middle and east parts of the region were lava flows followed by the formation of deep tectonic troughs; upon a subsidence, the latter were filled up with coal-bearing sequences. Approximately at the Chelyabinsk meridian, the folded basement plunges under Mesozoic and Cenozoic deposits.

The paleogeographic environment of the region changed substantially in the Mesozoic and Cenozoic, when conditions favorable for a concentration of stable minerals in sediments emerged in two instances.

In the Lower Mesozoic, an intensive tectonic activity prevented a concentration of these minerals; accordingly, cheifly polymictic sediments were deposits — components of the Turinsk volcanic-sedimentary series and the Chelyabinsk coal-bearing series.

The next tectonic stage corresponds to a comparative stability of the Ural region and a slow subsidence of West Siberia. Under peneplain conditions of the Jurassic and Cretaceous, a thick kaolin-type weathering crust was developed in the Urals, accompanied by the deposition of kaolin clays and quartz sand and pebble beds enriched in resistant accessory minerals (the weathering crust formation). Formed during this tectonic stage in adjacent parts of the West Siberian plain were marine sediments, chiefly polymictic, less commonly pure quartz. These sediments are organized into the following formations: Kiyalinsk (Hauterivian — Barremian — Aptian?); Khantymansiysk (Albian — Cenomanian); Kuznetsovsk (Turonian); Slavgorodsk (Coniacian — Santonian); Fadyushinsk (Campanian); Gan'kinsk (Maestrichtian — Danian); Talitsk (Paleocene); Serovsk (lower and middle Eocene); Irbitsk (upper Eocene); and Chegansk (top of the upper Eocene and lower Oligocene).[3]

The next tectonic stage of this region is related to its slow uplift, the accumulation of a new kaolin-type weathering crust, a complete sea regressive littoral and continental deposits characterized by a quartz composition of their psephytic and psammitic material. These sediments are organized in the following formations: Kutanbulak and Chiliktinsk (middle Oligocene), and Naurzumsk and Chagraysk (upper Oligocene).

From the Miocene on, and in connection with climatic changes, kaoline weathering ceases, and sediments of the Aral (miocene) and Kustanay (Pliocene) formations, as well as Quaternary deposits, become progressively more polymictic.

The content (in per cent) of heavy terrigenous minerals in all these formations is given in Table 5.

The high value of the paleogeographic factor (about 30), characteristic of continental Mesozoic deposits in the weathering crust and the Maurzum formations, is determined by the fact that they originated in the weathering of a kaolin crust. The minimum value of this factor (0.44) is due to the predominance of physical weathering, in the Quaternary, resulting in a considerable amount of unstable minerals added to the sediments. The somewhat larger value of this factor for the Kustanay (1.07) and the Aral (1.85) formations suggests a greater amount of weathered

[3]Age of the formations is designated according to the stratigraphic table adopted by the 1956 Conference on the Stratigraphy of Siberia, refined by the author for the Ural region.

Table 5

Tectonic stages	I		II					
Local stratigraphic subdivisions	Turinsk series	Chelyabinsk series	Weathering crust continental formation	Kiyalinsk formation	Khantymansiysk formation	Kuznetsovsk formation	Slavgorodsk formation	Fedyushinsk formation
Number of analyses	13	11	7	5	3	3	2	2
Ilmenite	1.0	2.8	11.3	1.1	17.6	3.2	9.8	3.7
Leucoxene	0.9	0.9	2.4	1.1	6.6	0.2	5.2	4.9
Chromite	9.6	7.2	24.0	3.0	1.6	2 6	0.04	—
Zircon	0.3	1.3	7.6	0.4	11.6	1.2	1.8	1.8
Rutile	0.1	0.3	11.6	0.3	5.2	0.2	2.6	1.1
Disthene	—	0.1	12.5	—	2.7	0.2	1.1	0.9
Staurolite	0.1	0.9	17.0	—	0.5	0.7	6.9	0.5
Other stable minerals (octahedrite, brookite, sillimanite, tourmaline, spinel, andalusite, corundum, monazite, hematite)	3.5	4.0	5.2	10.5	4.0	16.0	2.7	1.0
Magnetite	11.6	15.0	1.5	21.3	0.3	6.2	1.0	1.5
Garnets	0.5	1.5	1.2	0.7	1.3	0.1	0.3	0.4
Epidote, zoicite	15.2	4.1	0.5	2.7	9.7	7.4	2.7	5.8
Amphiboles	0.3	0.6	0.1	2.1	1.7	4.6	0.4	0.5
Other unstable minerals (apatite, sphene, pyroxenes)	3.3	6.5	0.2	0.6	—	4.0	3.6	30.7
Authigenic minerals	54.0	54.8	0.2	56.3	37.6	53.8	61.8	46.5
Total heavy fraction, in kg/m^3 of rock	31	6.8	7.5	15.5	34.5	24.2	18.5	7.3
Total, stable minerals	15.5	17.5	91.6	16.4	49.8	24.3	30.14	13.9
Total, unstable minerals	30.9	27.7	3.5	27.4	13.0	22 3	8.0	38.9
Total, authigenic minerals	54.0	54.8	0.2	56.3	37.6	53.8	61.8	46.5
Grand total	100.4	100.0	95.3	100.1	100.4	100.4	99.94	99.3
Paleogeographic factor	0.5	0.63	26.2	0.6	3.82	1.08	3.92	0.36

material present in the denudation zone, during that time. The low value of this factor (3.1) for the Chagraysk formation is probably due to an appreciable incision of the river system, despite the parallel broad development of a kaolin weathering crust.

Somewhat different causes should be assigned for a low value of the paleogeographic factor in marine sediments, from the Kiyanlinsk through the Chegansk formations.

An analysis of geologic material from the east Uralian slope shows that marine abrasion, however, slight, did remove the weathering crust in many places. In so doing, it exposed Paleozoic rocks which became a source of such unstable minerals as magnetite, garnet, and epidote. The low content of amphiboles is apparently due to their instability under the marine conditions.[4]

Typical of marine sediments is the lowering of their paleogeogralhic factor down to 1 and even 0.36, during the transgression periods (the Kuznetsovsk and Fedyushinsk formations). Conversely, epochs of regression and comparative stability are usually characterized by a higher paleogeographic factor, up to 4.9. Regressive-marine to continental Kutanbulak and Chiliktinsk deposits are marked by very similar and rather high paleogeographic factors; however, individual analyses give a higher epidote content (up to 20%) as against its standard of 0 - 5%.

An analysis of the areal distribution of samples rich in epidote shows that they are associated with swell-like uplifts of the Chegansk formation. Thus the higher epidote content is obviously related to an erosion of this formation in its uplifted segments, unless the horizons samples there were transitional from it to the Chegansk formation, closer to the latter in their epidote content. In all other respects, the mineral content in the Kutanbulak and Chiliktinsk concentrates is comparatively consistent. This is not quite true for the Naurzumsk formation. Very inconsistent is the composition of concentrates from continental Mesozoic weathering crust and the Kustanay formations and Quaternary deposits; finally, low values of the Paleographic factor are characteristic of the Turinsk and Chelyabinsk

[4]O.S. Dana points out that glauconite is formed in the destruction of augite, hornblende, and mica, in littoral marine deposits.

TABLE 5 (concluded)

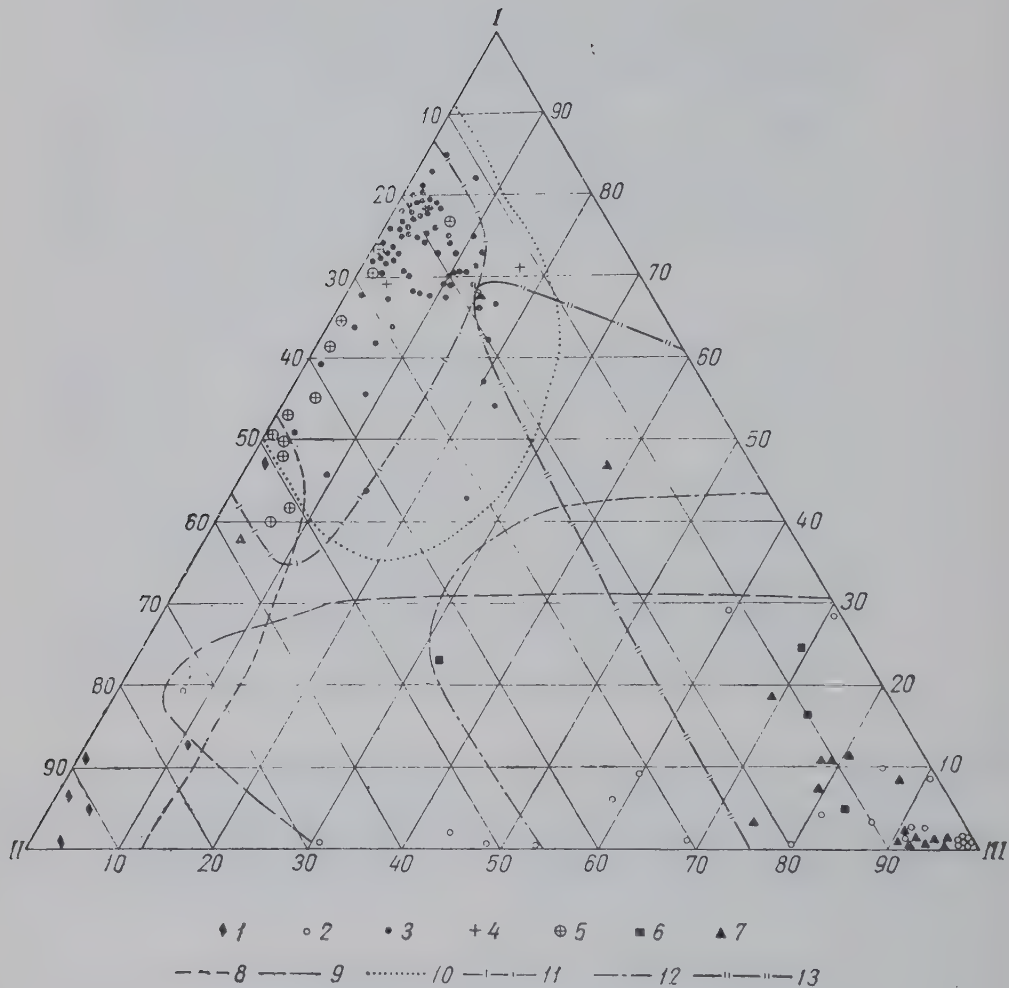
II					III				IV		
Gan'kinsk formation	Talitsk formation	Serovsk formation	Irbitsk formation	Chegansk formation	Kutanbulak formation	Chiliktinsk formation	Naurzumsk formation	Chagraysk formation	Aral formation	Kustanay formation	Quaternary deposits
5	3	12	4	14	97	6	19	12	10	14	30
24.8	20.5	19.2	34.2	37.5	68.0	58 0	45.2	18.9	23.6	16.5	13.5
3.2	12.4	10.8	18.6	2.0	5.5	0.8	3.3	3.0	6.5	1.5	0.5
1.5	1.0	3.4	0.9	0.05	0.3	0.02	1.0	0.3	1.3	—	0.9
4.4	7.1	4.9	2.8	6.8	7.7	9.0	9.1	3.2	8.4	4.9	4.8
3.4	2.9	4.1	2.7	3.9	5.2	4.5	4.9	2.7	3.9	5.5	2.6
2.6	4.2	4.4	4.0	6.5	4.0	8.1	11.2	6.4	6.6	10.7	2.8
5.6	2.8	5.5	2.2	2.1	4.4	7.5	18.7	16.0	7.2	9.0	3.2
2.6	—	12.3	2.7	1.5	2.5	4.3	2.3	1.8	3.1	3.4	1.1
7.0	5.6	6.2	0.9	2.4	2.2	1.7	1.7	1.0	21.4	4.0	2.5
0.5	1.3	4.2	2.6	5.2	0.9	2.4	0.4	9.3	3.1	5.8	12.5
6.8	2.1	8.2	28.2	28.5	3.5	3.9	0.8	1.9	6.3	22.0	16.6
1.9	1.0	2.2	0.8	1.0	0.5	0.6	0.4	3.0	1.4	14.6	32.0
0.1	0.4	6.1	0.2	Trace	0.1	Trace	0.1	1.2	0.9	1.7	3.1
35.7	37.9	9.3	0.2	0.8	—	—	0.3	31.9	6.4	—	—
8.0	12.6	46.0	1.8	3.13	13.6	9.8	8.5	52.0	10.8	27.0	28.5
48.1	50.9	64.6	68.2	60.35	97.6	92.32	95.7	52.3	60.6	51.5	29.4
16.3	10.4	26.9	32.7	37.1	7.2	8.6	3.4	16.4	33.1	48.1	66.7
35.7	37.9	9.3	0.2	0.8	—	—	0.3	31.9	6.4	—	—
100.1	99.2	100.8	101.1	98.25	104.8	100.92	99.4	100.6	100.1	99.6	96.1
2.96	4.9	2.4	2.1	1.63	13.5	10.7	28.0	3.1	1.85	1.07	0.44

series, formed chiefly by slightly weathered rocks, under the conditions of tectonic shifts.

These data suggest a direct fuctional relationship between the composition of terrigenous material and the content of material from the weathering of a kaolin weathering crust in the overall balance of eroded rocks. This relationship, derived from general theoretical consideration in Table 3, has been corroborated by concrete data. This relationship, as expressed in Mesozoic and Cenozoic rocks, is presented in Table 6.

Table 6

<table>
<tr><th colspan="2" rowspan="3">Main factors</th><th rowspan="3">Relative quiescence</th><th colspan="4">Tectonics</th></tr>
<tr><th rowspan="2">Minor uplifts</th><th colspan="2">Subsidence</th><th rowspan="2">Considerable uplifts or shifts</th></tr>
<tr><th>Without transgression</th><th>Active sea transgression</th></tr>
<tr><td rowspan="3">Climate</td><td>Temperate to cold</td><td>Aral form. (Q + M)</td><td>Kustanay form. (Q + M) Quaternary deposits (Q + M)</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">Warm and humid</td><td colspan="3">The weathering crust continental formation (M)</td><td rowspan="2">Khantymansiysk Kuznetsovsk, Slavgorodsk Fedyushinsk, Gan'kinsk, Talitsk, Serovsk, Irbitsk and Chegansk formations (Q + M)</td><td rowspan="2">Turinsk Series (Q + M) Chelyabinsk and Kiyalinsk formations (Q + M)</td></tr>
<tr><td>Naurzumsk formation (M)</td><td>Katanbulak and Chiliktinsk formations (M) Chagraysk formation (Q + M)</td><td>-</td></tr>
</table>



Ternary diagram of the concentrate composition for various stratigraphic horizons from the South Urals continental Mesozoic and Cenozoic.

I) group, ilmenite + leucoxene; II) group, chromite + zircon + rutile + disthene + staurolite + other stable minerals; III) group of unstable minerals. Concentrates: 1 - the weathering crust formation deposits; 2 - Turinsk and Chelyabinsk series; 3 - Kutanbulak formation; 4 - Chiliktinsk formation; 5 - Naurzumsk formation; 6 - Kustanay formation; 7 - Quaternary deposits; 8 - field formations of crust erosion; 9 - Turinsk and Chelyabinsk segment; 10 - Kutanbulak segment; 11 - Naurzumsk segment; 12 - Kustanay segment; 13 - Quaternary segment.

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Thus the paleogeographic factor is a criterion of the stratigraphic position of a sedimentary sequence. In addition the latter can be illustrated by a ternary diagram. In compiling such a diagram, the author has successfully used the following parameters: ilmenite + leucoxene; a group of other stable minerals (chromite, zircon, rutile, disthene, staurolite, and other less common ones); and a group of unstable minerals (magnetite, garnet, epidote, amphiboles, and other less common ones). Marine sediments, as represented in a ternary diagram, do not produce typical areas.

The proposed method of work by utilizing the ratio of stable to unstable minerals requires further check, in other areas. The important thing is to determine the degree of stability for various minerals under different climatic conditions or, in other words, for different profiles of ancient weathering. It appears that best results will be obtained from a combination of this method and that proposed by Illing and developed by V. P. Baturin.

For a corroboration of our thesis, we turn to the classical works of Edelman, abstracted in Russian by V. P. Baturin [2]. He connects Edelman's group "B Schemde", consisting exclusively of stable minerals with erosion of a Mesozoic land. The paleogeographic factor for this group turns out to be 49, which would suggest the formation of its minerals out of a weathering crust. In the light of our thesis, the sharp difference between the composition of mineral associations from the Netherlands Eocene (rich in stable minerals) and marine Oligocene and Mio-Pliocene (K = 0.18) sediments is readily understood. Equally clear becomes the difference in the formation conditions for groups "B Limburg" and "B Elsloo". Edelman associates both of them with the Ardennes erosion; however, in the first instance, K = 49 as against K = 0.37, in the second. Edelman did not take into account the fact that the composition of accessory minerals undoubtedly has been affected by ancient erosion. Because of that, some of his conclusions will have to be revised, along with those arrived at on the basis of similar studies.

* * *

The proposed petrographic method is based on the part played by ancient weathering crust in the formation of accessory minerals in sediments. It can be used successfully in regions which have undergone ancient weathering of a kaoline type.

REFERENCES

1. Aliyev, A. G., Petrografiya sarmatskikh otlozheniy Zapadnogo Azerbaydzhana. [PETROGRAPHY OF SARMATIAN DEPOSITS IN WEST AZERBAYDZHAN]: Izd. Akad. Nauk Azerb. SSSR, 1949.

2. Baturin, V. P., Paleogeografiya po terrigennym komponentam. [PALEOGEOGRAPHY BY TERRIGENOUS COMPONENTS]: Izd. Azerb. ONTI, 1937.

3. Baturin, V. P., Petrograficheskiy analiz geologicheskogo proshlogo po terrigennym komponentam. [PETROGRAPHIC ANALYSIS OF GEOLOGIC PAST, BY TERRIGENOUS COMPONENTS]: Izd. Akad. Nauk SSSR, 1947.

4. Bushinskiy, G. I., Teoriya A. D. Arkhangel'skogo o genezise boksitov v svete sovremennykh dannykh [A. D. ARKHANGEL'SKOGO'S THEORY OF THE ORIGIN OF BAUXITES IN THE LIGHT OF RECENT DATA]: Sb., "Boksity, ikh mineralogiya i genezis". Izd. Akad. Nauk SSSR, 1958.

5. Vikulova, M. F., Veshchestvennyy sostav i morfologiya zalezhey ogneupornykh glin nizhnego karbona Borovichesko-Lyubytinskogo rayona. [THE MATERIAL COMPOSITION AND MORPHOLOGY OF LOWER CARBONIFEROUS REFRACTORY CLAY DEPOSITS IN THE BOROVICHI-LYUBYTINSK AREA]: Litol. sb., v. I, Gosgeolizdat, 1940.

6. Gridnev, N. I., Litologiya kaynozovskikh molass Surkhandar'inskoy Depressii. [LITHOLOGY OF CENOZOIC MOLASSE FROM THE SURKHANDAR'INSK TROUGH]: Avtoreferat Izd. UzSSR, 1951.

7. Malyshev, I. I., Zakonomernosti obrazovaniya i razmeshcheniya mestorozhdeniy titanovykh rud. [REGULARITIES IN THE FORMATION AND DISTRIBUTION OF TITANIUM ORE DEPOSITS]: Gosgeoltekhizdat, 1957.

8. Milner, G. B., Petrografiya osadochnykh porod. [PETROGRAPHY OF SEDIMENTARY ROCKS]: ONTI, 1934.

9. Obruchev, V. A., K voprosu o sposobe peredvizheniya boleye grubykh osadkov vdol' beregov vodnykh basseynov. [THE METHOD OF TRANSPORTATION OF COARSER SEDIMENTS ALONG THE SHORES OF SEDIMENTARY BASINS]: Izv. Tomsk. Tekhndl. in-ta, t. 13, v. 1, 1909.

10. Reyborn, K. and G. Milner, Poiski i

razvedka allyuvial'nykh mestorozhdeniy. [PROSPECTING AND EXPLORATION FOR PLACER DEPOSITS]: ONTI, 1933.

11. Sarkisyan, S.G. and G.A. Shapovalova, Petrografiya maykopskikh i sarmatskikh otlozheniy Vostochnoy Gruzii i paleogeografiya vremenii ikh obrazovaniya. [PETROGRAPHY OF MAIKOP AND SARIMATIAN DEPOSITS OF EAST GEORGIA AND THE CONTEMPORANEOUS PALEOGEOGRAPHY]: Izd. Akad. Nauk SSSR, 1952.

12. Sarkisyan, S.G., Mineralogiya osadochnykh porod i neftyanaya promyshlennost' SSSR. [MINERALOGY OF SEDIMENTARY ROCKS AND THE PETROLEUM INDUSTRY]: Sb. "Voprosy mineralogii osadochnykh obrazovaniy, Vols. 3 and 4, L'vovsk. un-ta, 1956.

13. Sigov, A.P., K voprosu primeneniya promyshlennogo prognoza po terrigennym komponentam. [APPLICATION OF INDUSTRIAL FORECASTING OF MINERAL DEPOSITS BY TERRIGENOUS COMPONENTS]: "Razvedka i okhrana nedr", no. 10, 1956.

14. Mackie, W., The feldspars present in sedimentary rocks as indicators of the conditions of contemperaneous climates: Trans. Edinburg Geol. Soc. VIII, 1899.

REGULARITIES IN THE DISTRIBUTION OF NONFERROUS AND PRECIOUS METALS IN PRINCIPAL ORE MINERALS AND SILICATES OF THE NORIL'SK DEPOSITS[1]

by

V.L. Ginzburg and G.B. Rogover

REVIEWER'S NOTE

Good basic geochemical evaluation of metals and their distribution in the Noril'sk deposit. Order of decreasing trace element content in sulphides is Cu, Ni, Pa, Au, Co, and Pt.

ABSTRACT

The results of a study of copper, nickel, cobalt, platinum, palladium, gold, and rhodium distribution in basic ore-forming sulfide minerals (chalcopyrite and pyrrhotites) as well as in the silicate portion of the host rocks of the Noril'sk deposit, are given. Interrelations between metals in different sulfide minerals and silicates are characterized. It has been established that palladium, platinum, and gold are concentrated in chalcopyrite while cobalt and rhodium are concentrated in pyrrhotite. The cobalt and precious metal content in sulfides grows with the increase of their nickel content. The relative content, however, of all these elements estimated for 1% of nickel is different in chalcopyrites and pyrrhotites. The former show a high platinum, palladium, and gold content and the latter--cobalt and rhodium. Ratios of these elements in sulfides and silicates are different. The relative platinum content increases in silicates due to a considerably greater content of mineralized platinum. Both nickel and cobalt form silicate compounds the latter to a much greater extent than the former. The relative cobalt content is therefore higher in silicates than in sulfides. In descending order, the element concentrations in sulfides range as follows: copper, nickel, palladium, gold, cobalt, platinum. --Auth. English summ.

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This paper summarizes the results of a study undertaken for the purpose of characterizing main ore-forming minerals and their enclosing rocks, by their non-ferrous and precious metals, in order to obtain a more or less definite idea of the relationship between such metals as well as the regularities in their distribution in sulfides, silicates, and the geologic section of the Noril'sk deposit.

The study material was represented by samples of sulfides characteristic of the main associations of ore minerals peculiar to each ore-bearing rock as well as of the sulfide fraction of the sulfide-carrying rocks themselves.

Because of the impossibility of separating mineral fractions, samples from sulfide incrustations, veinlets, and veins were taken on the basis of microscopic determinations, individually, with the predominance of principal ore-forming mineral as a criterion. Using the same criterion, they were designated as pyrrhotite, chalcopyrite and mixed pyrrhotite-chalcopyrite. Inaccuracies in assigning the samples to this or that group were eliminated in the subsequent chemical analyses. Thus, samples with a copper content of over 25 - 26% were designated as essentially chalcopyritic; those with a copper content up to 4 - 5%, essentially pyrrhotitic. All intermediate samples were designated as mixed pyrrhotite-chalcopyrite.

Three analytical methods were used in determining the composition of sulfide and silicate samples: the spectrum method, for copper, nickel, cobalt, zinc, lead, tin, and other elements; the spectrochemical, for gold, platinum, palladium, and rhodium; and the chemical, for copper, nickel, and cobalt.

The results cited below were obtained by spectrum and spectrochemical analyses carried out by N. I. Vitushkina, Ye. F. Nagiyeva, M. S. Gerasimova, and S. E. Kashlinskaya, under the direction of V. L. Ginzburg; and chemical analyses by M. I. Litvinskaya and A. I. Sudakov.

RESULTS OF THE ANALYSES

Results of the analyses for sulfide samples are listed in Table 1 where the samples are grouped by ore-bearing rocks arranged, reading downward, as they occur in the geologic section.

The data in Table 1 show that 90% of chalcopyrite samples do not contain rhodium, while 90% of pyrrhotite samples do. It obviously follows that rhodium is an element essentially related to pyrrhotite.

The opposite is true for gold and palladium. In chalcopyrite samples, the palladium content

[1]Translated from Sovetskaya Geologiya, 1960, no. 3, p. 48-60.

TABLE 1

Rocks	Number of Samples	Content in 1% nickel					
		Cu, %	Co, %	Au, g/ton	P, g/ton	Pd, g/ton	Rh, g/ton
Chalcopyrite samples							
Gabbro	—	—	—	—	—	—	—
Gabbro-diorite	1	7.1	0.01	3.4	4.5	9	None
Olivine gabbro-diabase	1	3.2	0.01	1.9	3.4	24	0.4
Picrite gabbro-diabase	—	—	—	—	—	—	—
Taxitic gabbro-diabase	1	8.1	0.013	2.7	10	35	None
Contact gabbro-diabase	2	7.7	0.016	0.8	1.7	33	Trace
Labradorite porphyrite	8	8.8	0.012	2.0	7.0	30	None
Titano-augitic diabase	3	9.3	0.012	1.1	2.4	23	"
Andesine diabase	11	7.6	0.012	3.1	3.9	38	0.4
Pyrrhotite-Chalcopyrite samples							
Gabbro	1	0.77	0.014	1.4	1.3	19	0.2
Gabbro-diorite	—	—	—	—	—	—	—
Olivine-biotite gabbro-diabase	1	2.8	0.018	1.0	2.0	13	0.6
Picrite gabbro-diabase	6	1.5	0.020	0.4	2.2	11	1.1
Taxitic gabbro-diabase	8	3.6	0.023	0.8	2.0	16	0.9
Contact gabbro-diabase	8	3.7	0.033	0.6	1.4	15	0.54
Labradorite porphyrite	5	5.6	0.030	1.6	3.4	12	0.33
Titano-augitic diabase	—	—	—	—	—	—	—
Andesine diabase	—	—	—	—	—	—	—
Pyrrhotite samples							
Gabbro	—	—	—	—	—	—	—
Gabbro-diorite	—	—	—	—	—	—	—
Olivine-biotite gabbro-diabase	2	0.6	0.020	0.09	1.6	5	1.0
Picrite gabbro-diabase	3	0.30	0.024	0.11	0.6	7	1.1
Taxitic gabbro-diabase	4	0.31	0.024	0.10	1.4	6	0.8
Contact gabbro-diabase	3	0.36	0.030	Trace	0.5	2.2	3.0
Labradorite porphyrite	7	0.42	—	0.02	0.6	3.0	1.2
Titano-augitic diabase	—	—	—	—	—	—	—
Andesine diabase	—	—	—	—	—	—	—
Pyrite samples							
Effusive diabase, gabbro, labradorite porphyrite	4	Trace	50-75	3.4	270	15	Trace

for 1% nickel is 31 g/ton, on the average, while it does not exceed 5 g/ton for the pyrrhotitic samples. Chalcopyrite samples are much richer in gold and platinum, both in the absolute and relative contents for 1% nickel.

Cobalt behaves like radium, being associated with pyrrhotite. Its average absolute content in pyrrhotite samples is 3 to 5 times greater than in the chalcopyrite.

Very characteristic of all sulfide samples, with the exception of pyritic, is the definite predominance of palladium over platinum. The relative contents (for 1% nickel) of copper, cobalt, and palladium in chalcopyrite samples is sufficiently constant, which suggests a more or less uniform composition of chalcopyrite in all ore-bearing rocks.

Sulfide samples, assigned to an inseparable blend of pyrrhotite and chalcopyrite, by their macroscopic features and by their copper content (5 to 25%), are likewise intermediate between the two, in heir other features. This confirms the wisdom of the classification adopted.

Standing out by themselves are pyritic samples. Unfortunately, they are very few, and the conclusions pertaining to them should be regarded as merely preliminary. The cobalt content in these samples is up to 50% and over, of that for nickel. They carry little palladium and somewhat more platinum. This situation seems to prevail in pyrite from all varieties of gabbro-diabases and the underlying rocks.

Pyrite is known to carry cobalt minerals. It is also true that the crystalline lattice of CoS_2 coincides with that of pyrite. A similar lattice is present in RhS_2. Consequently, an increase in the cobalt content may be accompanied by that of rhodium.

REGULARITIES IN THE DISTRIBUTION OF ELEMENTS IN SULFIDES

Cobalt. Regularities in the distribution of cobalt in sulfide samples, along with the relationship between cobalt and nickel, are illustrated in graph of Fig. 1, where nickel and cobalt contents are plotted for all sulfide samples analyzed for them.

This graph shows clearly that the cobalt content in all chalcopyrite samples is lower than in the pyrrhotite, and that the points of chalcopyrite-pyrrhotite samples fall between those for the chalcopyrite and pyrrhotite samples. Inasmuch as the cobalt-nickel straight line for chalcopyrite samples passes almost through the point of origin, it may be assumed that the zero nickel content corresponds to the zero cobalt content. This indicates, in turn, that there are no independent cobalt minerals related to charcopyrite, and all cobalt of the charcopyrite samples is related to sulfides of nickel, where it isomorphously replaces the latter.[2]

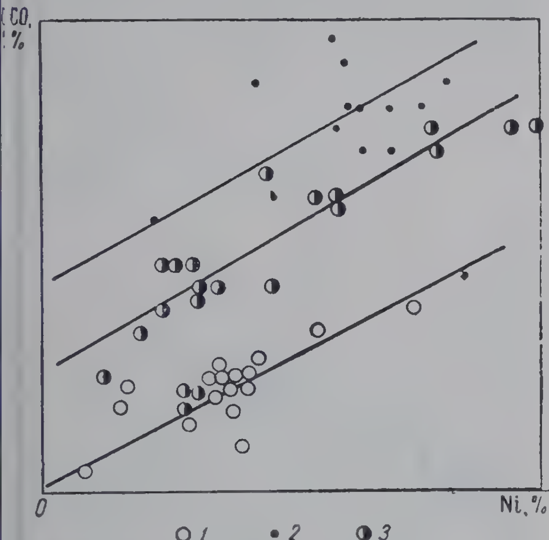

FIGURE 1. Cobalt content as a function of the nickel content.

Symbols: 1 - chalcopyritic; 2 - pyrrhotitic; 3 - pyrrhotite-chalcopyritic

A similar cobalt-nickel straight line for the pyrrhotite samples does not pass through the point of origin. Consequently, cobalt should be present in pyrrhotite samples with a zero nickel content. In other words, it may be assumed that, along with cobalt which isomorphously replaces nickel in nickel sulfides, pyrrhotite also carries cobalt which either forms independent nickel minerals or else is closely bound with the pyrrhotite itself. A similar bond has been established also for the pyritic samples which carry a comparatively large amount of cobalt for their low nickel content.

Rhodium. In the nickel-cobalt graph, the pyrrhotite sample points turned out to be very scattered, rendering very difficult their use for the regularities' determination. However, the fact that the rhodium content increases with a general increase in the nickel content in pyrrhotite is reflected quite definitely.

A close relationship between rhodium and cobalt may be assumed on the basis of their approximately similar distribution in minerals.

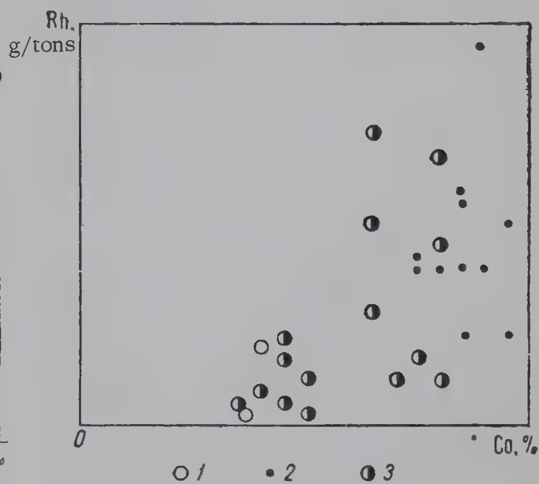

FIGURE 2. Rhodium content as a function of the cobalt content.

Symbols the same as in Fig. 1.

However, a rhodium-cobalt graph (Fig. 2) shows that rhodium appears only in samples carrying a certain definite amount of cobalt. It may be concluded, then, that some of the cobalt is not related to rhodium.

Palladium. The nature of the palladium distribution in sulfides is clearly established by means of an appropriate graph illustrating the growth in its content for all sample groups, in conformity with that of nickel, thus suggesting a quite definite relationship between these two elements.

However, the relative content of palladium for 1% nickel in chalcopyrite samples is six times greater than in the pyrrhotite.

A graph illustrating the palladium-copper relationship (Fig. 3) shows that chalcopyrite

[2]Pentlandite is the principal nickel-carrying sulfide in all ore-bearing rocks with the exception of andesine diabase where the nickel-carrying sulfide is millerite.

samples are marked by a higher palladium-nickel ratio than the pyrrhotite samples. This suggests a palladium-carrier in chalcopyrite, which is missing in pyrrhotite.[3] At the same time, the dispersed palladium is bound chiefly to nickel, i. e., to pentlandite and millerite; in addition, it is present in ores as an individual sulfide.

Platinum. A platinum-nickel graph does not reveal any regularity in the distribution of platinum. It can only be stated that the platinum content in most chalcopyrite samples is considerably higher than in the pyrrhotite. The lack of a correlation between platinum and nickel suggests that, along with dispersed platinum, associated with sulfides, there are individualized platinum minerals whose distribution does not depend on that of the sulfides.

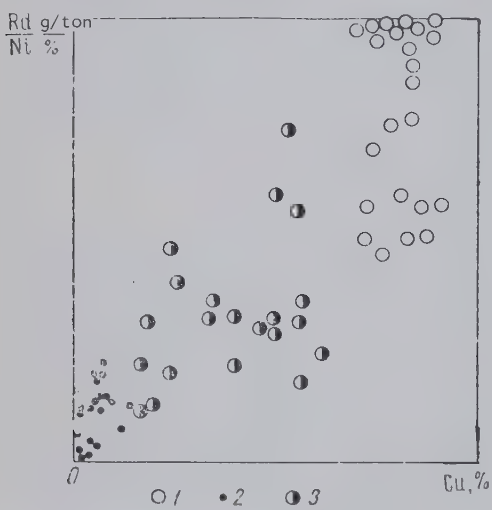

FIGURE 3. Palladium content as a function of the copper content.

Symbols the same as in Fig. 1.

This is in fair agreement with the fact that most platinoid group minerals under study are those represented by polyxens of Pt and Fe, stannoplatinite Pt_3Sn, nickel and palladium platinum, braggite (Pt, Pd, Ni) S, cooperite PtS, sperrylite $PtAs_2$, and some other minerals.

There is no relationship between platinum and copper, as there is none for platinum and palladium. As to the platinum--palladium ratio in the chalcopyrite and pyrrhotite samples, it is 0. 14 and 0. 20, respectively.

Iridium, ruthenium, osmium. The distribution of these elements in our samples has not been studied, as yet. Iridium is missing in placer platinum; however, it was detected by V. L. Ginzburg in cooperation with N. I. P'yankov, in soluble products of technological processes. According to M. N. Godlevskiy, ruthenium was observed by A. D. Genkin as laurite RuS_2, very rare in chalcopyrite veins, in association with native gold and other rare minerals. Osmium was observed by A. N. Fedorova in slag products of copper and nickel electrolysis.

Gold. On a gold-nickel graph, the points show the same haphazard distribution as on the platinum distribution graph. It appears, nevertheless, that on the average the gold content, too, is considerably higher in chalcopyrite samples than in the pyrrhotite. This makes it

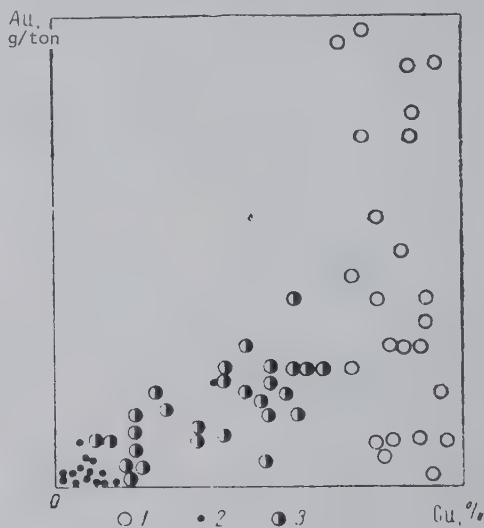

FIGURE 4. Gold content as a function of the copper content.

Symbols the same as in Fig. 1.

possible to postulate a direct relationship between gold and copper sulfates. However, within the chalcopyrite samples group, too the points are well scattered (Fig. 4); this apparently suggests a large number of gold particles in chalcopyrite samples, not related to sulfides.

Silver. An approximate quantitative estimate of the spectrum analysis data shows that silver is present in all sulfide samples, in the amount exceeding 5 - 10 g/ton. M. N. Godlevskiy, in assuming that silver, like gold, is bound in some way to platinum metals and partially enters the composition of the same tellurides, notes at the same time its complete independence of lead, despite the presence of galena in the ores. This is corroborated by the relationship graph as well as a sharp difference in the concentration indices for these metals.

[3]Inasmuch as the palladium content may vary for the same copper content, the palladium content for 1% nickel is plotted along the vertical axis, rather than its absolute content.

The distribution of these elements in chalcopyrite, chalcopyrite-pyrrhotite, and pyrrhotite samples is shown in Table 2, which gives their relative content in each of the three sample groups.

TABLE 2

Samples	Cu	Ni	Co	Au	Pt	Pd	Rh
Chalcopyrite......................	13	1	1	20	3	4	1
Pyrrhotite-chalcopyrite...........	4.5	1.5	2.5	6	2	2	2
Pyrrhotite........................	1	1.5	3.3	1	1	1	25

Zinc, lead, tin. Spectrum analyses have been carried out for these metals. Their maximum content is associated with chalcopyrite samples; the minimum, in the pyrrhotite; with mixed pyrrhotite-chalcopyrite samples characterized by intermediate contents of these elements. Most prominent in sulfide samples is zinc, followed by lead and then tin.

The content of zinc, lead, and tin in sulfide samples is shown in Table 3.

TABLE 3

Samples	Zn	Pb	Sn
Chalcopyrite......	0.005—0.01	0.003—0.005	0.001
Pyrrhotite........	0.002—0.005	0.002—0.003	less than 0.001

COMPOSITION OF PRINCIPAL MINERALS IN VEINS AND INCRUSTATIONS

When a deposit carries two types of ores, represented by either dispersed or massive sulfides, localized in veins, the question arises as to a possible difference in the composition of principal ore minerals, the components of such ores. In this connection, relative contents of copper, nickel, cobalt, gold, platinum, palladium, and rhodium, for 1% nickel, and for 1% copper in the chalcopyrite and pyrrhotite samples, taken from veins and incrustations were calculated.

All these data are listed in Table 4 and 5.

As seen from Tables 4 and 5, the chalcopyrite and pyrrhotite samples do not differ substantially in their content of copper, nickel, and cobalt; and that of gold and palladium, in part. However, even the small differences in the composition of chalcopyrite and pyrrhotite from incrustations and veins may suggest that the composition of these minerals in veins is more true to type than that of the same minerals from incrustations. Indeed, the maximum copper content and the minimum cobalt content, both absolute and relative (for 1% nickel), have been observed in the vein chalcopyrite samples; conversely, the minimum copper content and the maximum cobalt content are peculiar to the pyrrhotite vein samples.

Such a difference in the composition of the same minerals in incrustations and veins can be explained by the presence of pyrrhotite inclusions in the incrustation chalcopyrite, and of inclusions of copper sulfides in the incrustation pyrrhotite; in other words, by the lower degree of purity in the incrustation minerals, brought about by an incomplete differentiation of the sulfide mass in incrustations into chalcopyritic and pyrrhotitic fractions, at the instant of its crystallization. These differences are corroborated also by the distribution of platinum and rhodium in these minerals. The vein chalcopyrite contains the most platinum, with rhodium missing; on the other hand, the vein pyrrhotite carries the most rhodium and the least platinum. The platinum content in the vein chalcopyrite is almost twice as large as that in the incrustation chalcopyrite, while its content in the vein pyrrhotite is half as

TABLE 4

Samples	Content in 1% nickel					
	Cu, %	Co, %	Au, g/ton	Pt, g/ton	Pd, g/ton	Rh, g/ton
Chalcopyrite						
from veins..................	8.6	0.011	2.3	6.8	32	0
from incrustations...........	7.5	0.014	2.6	4.0	35	0.26
Pyrrhotite						
from veins..................	0.33	0.042	0.04	0.7	3.1	2.2
from incrustations...........	0.39	0.030	0.10	1.1	5.8	1.0

TABLE 5

Samples	Ni, %	Co, %	Au, g/ton	Pt, g/ton	Pd, g/ton	Rh, g/ton
Chalcopyrite						
from veins..................	0.12	0.0013	0.26	0.8	3.7	0
from incrustations...........	0.13	0.0018	0.35	0.5	4.6	0.04
Pyrrhotite						
from veins..................	3.0	0.12	0.13	2	10	7
from incrustations...........	2.6	0.008	0.27	3.0	15	2.6

large as that in the incrustation pyrrhotite. The platinum-palladium ratio in the vein chalcopyrite is 1:4.7 as against 1:8.8 in the incrustation chalcopyrite. Differences between pyrrhotites from vein and dispersed ores have also been established by the distribution in them of rhodium, whose content in the first type is twice that of the second.

These differences in the composition of chalcopyrites and pyrrhotites from veins and incrustations cannot be explained by a mutual "contamination" of the incrustation minerals; they evidently reflect differences in the genetic and geochemical conditions of the formation of dispersed and massive ores.

A graph (Fig. 5) illustrates the relationship between relative contents of rhodium and cobalt in the chalcopyrite and pyrrhotite samples from veins and incrustations.

This graph shows that the relative content of rhodium (for 1% nickel) is proportional to that of cobalt, thus suggesting an isomorphous replacement of nickel sulfides by rhodium and

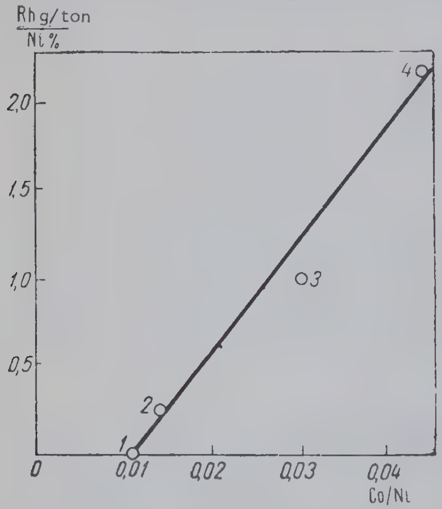

FIGURE 5. Relationship between relative contents of rhodium and cobalt in the chalcopyrite and pyrrhotite samples taken from veins and incrustations.

Chalcopyrite samples: 1 - from veins; 2 - from incrustations; Pyrrhotite samples: 3 - from incrustations; 4 - from veins.

cobalt. However, inasmuch as this proportionality is valid only for relative contents of cobalt, exceeding 0.011%, it may be assumed that there exist cobalt minerals not associated with rhodium.

DISTRIBUTION OF ELEMENTS IN THE SILICATE FRACTION OF ORE-BEARING MINERALS

Present in samples of ore-bearing rocks are sulfide minerals which escape the naked eye. At the same time, all sulfide samples are not pure sulfides, but carry silicate additions.

It has been shown analytically that the silicate content in sulfides is small, not exceeding 5% of the total, by weight. The proportion of sulfide inclusions in silicate samples also is apparently small. All that is fully substantiated by the ratios of these two groups in samples. If non-ferrous and precious metals are present in silicate samples solely as finely-dispersed sulfides, of the same type as those sampled, the ratios between metals in the sulfide and silicate samples will be the same.

For a correlation of the contents of non-ferrous and precious minerals, they were converted to their ratios to nickel, for each group of samples. The data so obtained are listed in Table 6, where copper and cobalt have been computed in per cents for 1% nickel, while gold, platinum, and palladium have been calculated in g/ton for 1% nickel.

Table 6 shows that the relative content of cobalt and platinum in the silicate fraction is substantially higher than in the sulfide samples. Relative contents of gold and palladium in silicate samples are either close to hat characteristic of sulfide samples or else exceed it. The relative content of copper in silicate samples is always lower than in the sulfide ones.

Thus, the ratios of elements in the silicate and sulfide samples show quite definite differences, due to the dissimilar nature of mineral formations for non-ferrous and precious metals, components of the sulfide and silicate fractions of ore-bearing rocks.

Microscopic studies have established the presence of finely-dispersed sulfides in the silicate

TABLE 6

Samples	Sulfide samples					Silicate samples				
	Cu	Co	Au	Pt	Pd	Cu	Co	Au	Pt	Pd
Gabbro, gabbro-diorite, olivine gabbro-diabase, olivine-biotite gabbro-diabase . .	1.8	0.021	1.1	2.6	13	1.0	0.10	0.75	10	5
Picritic gabbro-diabase	1.1	0.021	0.3	1.7	10	1.1	0.07	1.3	8	22
Taxitic gabbro-diabase	2.3	0.024	0.6	2.5	14	1.05	0.045	1.4	14	11
Contact gabbro-diabase	3.3	0.029	0.5	1.2	14	1.6	0.08	2.6	38	36
Labradorite porphyrite	5.1	0.012	2.1	7.3	31	3.1	0.06	1.8	11	23
Titano-augitic diabase	9.3	0.012	1.1	2.4	23	2.6	0.015	1.1	11	21
Andesine diabase . .	7.6	0.012	3.5	4.0	38	2.2	0.025	3.3	15	36
Average for all samples	3.6	0.022	1.1	2.7	17.0	1.8	0.044	1.9	14	23

fraction of ore-bearing rocks. However, on the basis of the known differences in the ratios between elements in sulfide and silicate samples, it can be assumed that these elements are present in the silicate fraction not only as finely dispersed sulfides, but also as other forms, which increases their relative content in the silicate samples.

In order to determine the ratio of elements from the silicate fraction of ore-bearing rocks to those from the sulfide and other fractions, it is necessary to separate them from the total content of each element the fraction allotted to that element when it occurs in the same ratios to other elements as those characteristic of sulfide samples. With this in mind, we compute the relative content of all elements for 1% copper, inasmuch as all copper in the silicate fraction of ore-bearing rocks occurs only in dispersed sulfides. The latter fact is corroborated by the data of Table 6, which suggest lower relative contents of copper in silicate samples, as compared with the sulfide; it also has been corroborated by mineralogical and chemical studies.

Relative contents of nickel and cobalt for 1% copper, in per cents, and for gold, platinum, and palladium, in grams per ton (metric), are given in Table 7.

Table 7 shows clearly that the content of all five elements--nickel, cobalt, gold, platinum, and palladium--for 1% copper, is considerably higher in silicate samples than in the sulfides.

As pointed out before, this can be explained by the fact that each of these elements may be present in two forms, in silicate samples: as a sulfide and in some other form.

We shall now attempt to separate that part of the total average content of each element for all silicate samples, contained in finely dispersed sulfide inclusions, and the residual content determined by other factors, with a stipulation that the relative content of these elements (for 1% copper) in a sulfide form is to be the same as in the sulfide samples.

Such a differentiation has been accomplished in Table 8.

In this table, each element is assigned three figures: 1) total content, an average of the analyses of all samples; 2) calculated content, allotted to finely dispersed sulfides and obtained by multiplying the average copper content in silicate samples by the relative content of each of their elements for 1% copper; 3) residual content--the difference between the first two.

The nature of this residual content is different for different elements. For platinum, this is explained by the presence of individualized minerals not related to the sulfides. These minerals

TABLE 7

Samples	Sulfide samples					Silicate samples				
	Ni	Co	Au	Pt	Pd	Ni	Co	Au	Pt	Pd
Gabbro, gabbro-diorite, olivine gabbro-diabase, olivine-biotite gabbro-diabase . .	0.55	0.012	0.6	1.45	7.2	1.0	0.10	0.75	10.0	5.0
Picritic gabbro-diabase	0.91	0.019	0.3	1.55	9.1	0.91	0.065	1.2	7.3	20
Taxitic gabbro-diabase	0.44	0.011	0.3	1.1	6.1	0.95	0.04	1.3	13.0	10.0
Contact gabbro-diabase	0.30	0.009	0.15	0.36	4.3	0.63	0.05	1.6	24.0	23.0
Labradorite porphyrite	0.20	0.002	0.4	1.4	6.1	0.32	0.02	0.58	3.5	7.4
Titano-augitic diabase	0.11	0.001	0.12	0.26	2.5	0.38	0.006	0.42	4.2	8.4
Andesine diabase . .	0.13	0.002	0.46	0.52	5.0	0.45	0.011	1.5	6.8	16.3
Average for all samples	0.28	0.006	0.3	0.75	4.8	0.55	0.024	1.05	7.8	12.7

were extracted in the processing of the Noril'sk ores by the gravity enrichment method, as the so-called concentrate platinum whose distribution in ore-bearing rocks is not subject to any regularities.

As to the palladium residual content, the only positive statement that can be made is that some of it is connected with the concentrate platinum, being 25 - 33% of the latter's content, according to the analyses.

The residual gold content, too, appears to be related to a considerable extent to concentrate platinum.

The residual content of nickel and cobalt is determined by the presence of their silicate

TABLE 8

Content in %								
Cu			Ni			Co		
total	computed	residual	total	computed	residual	total	computed	residual
0.18	0.18	None	0.10	0.05	0.05	0.0044	0.001	0.0034

Content in g/ton								
Au			Pt			Pd		
total	computed	residual	total	computed	residual	total	computed	residual
0.19	0.05	0.14	1.4	0.13	1.27	2.3	0.8	1.5

compounds in the Noril'sk ores. It should be noted that the proportion of silicate nickel in total nickel is considerably lower than the proportion of silicate cobalt. This is corroborated by figures of Table 8 which show that the ratio of silicate cobalt (0. 0034%) to silicate nickel (0. 05%) is 0. 07, while it is 0. 0125 in sulfide samples and 0. 03 in pyrrhotite, the richest in cobalt.

No analyses for rhodium have been made in silicate samples. However, since the rhodium behavior in sulfides is similar to that of cobalt, the existence of a silicate rhodium can be assumed. This was first suggested by O. D. Zvyagintsev. M. N. Godlevskiy, in referring to the higher rhodium-nickel ratio in picrite gabbro-diabase, also noted the possibility of such rhodium.

The zinc content in silicate samples varies from 0. 002 to 0. 005%; the lead content, from 0. 002 - 0. 004%. Tin is present in these samples in the amount of no less than 0. 001%.

THE DEGREE OF CONCENTRATION OF ELEMENTS IN SULFIDES

The degree of concentration of these elements in s ulfides can be judged from the ratio of their content in sulfide samples to that in the silicate. For copper, it is 90; for nickel, 45; cobalt, 23; gold, 25; platinum, 9; and palladium, 32.

These figures indicate that copper, as the most chalcophilic, has the highest tendency for concentration.

Nickel, present in ores as a sulfide or a silicate, is characterized by a smaller degree of concentration. Cobalt, with its even higher tendency for forming silicate compounds, is characterized by a considerably smaller degree of concentration in sulfide minerals, as compared with copper and nickel. The degree of concentration for platinum and palladium is determined by their capacity for forming individual sulfides. This is especially true for aplladium; and, because of that, the latter is characterized by a higher degree of concentration, as compared with gold and platinum. Platinum is the least capable of forming sulfides, which explains the low degree of its concentration in them. The lower degree of the palladium concentration, as compared with copper and nickel, can be explained by the fact that palladium, while forming sulfides, also enters the composition of platinum minerals not related to them. The gold concentration in sulfides is promoted by its relationship to chalcopyrite; however, the presence of gold in platinum minerals lowers the degree of its concentration in the sulfide minerals, as compared with copper and nickel.

SUMMARY

The main results of our study are as follows:

1. This method of study of sulfide samples without sampling the monomineral fractions, whose separation from silicates of the Norilsk ore is extremely difficult, affords insight into the composition of the most important ore minerals, the regularities of the distribution in them of various elements, and their mutual relationship. This will promote a further improvement in the technology of ore processing and their comprehensive utilization.

2. In differentiating sulfide minerals into chalcopyrites, pyrrhotites, and inseparable pyrrhotite-chalcopyrite blends, by their macroscopic features and copper content, it transpires that such a differentiation also is feasible by their contents of nickel, cobalt, gold, platinum, palladium, and rhodium.

3. Pyrrhotite samples, as compared with the chalcopyrite, are marked by substantially higher contents of cobalt (3 - 4 times) and rhodium (20 - 30 times).

4. As compared with the pyrrhotite samples, chalcopyrite samples are richer in copper (11 - 15 times), platinum and palladium (3 - 5 times), and especially gold (20 times). In addition, chalcopyrite samples carry much zinc, lead, and tin.

5. The content of cobalt, platinum, palladium, gold, and rhodium in sulfides grows with the nickel content. However, the relative content of these elements, calculated for 1% nickel, is different in chalcopyrites and pyrrhotites. Chalcopyrites have a high relative content of gold, platinum, and palladium, while pyrrhotites are richer in cobalt and rhodium.

6. The palladium-platinum ratio is considerably higher in sulfides than in silicates. The latter carry, along with the platinum of sulfides, individualized platinum minerals.

7. Present in pyrrhotite along with cobalt of the nickel sulfides are individual cobalt minerals. Cobalt forms silicate compounds more readily than nickel.

8. The palladium content in sulfides is 6 - 8 times that of the platinum, as against merely 1. 6 - 2. 2 times in the silicate samples. The growth of the relative content of platinum in silicates is due to the presence of individualized platinum minerals (concentrate platinum).

9. Chalcopyrite and pyrrhotite samples from veins are better characterized by the features of their respective groups than similar samples taken from the incrustations. This suggests different genetic and geochemical formation

conditions for dispersed and massive ores in sulfide veins.

10. In the order of their decreasing concentration in sulfides, non-ferrous and precious metal are arranged as follows: copper, nickel, palladium, gold, cobalt, and platinum.

Ministry of Geology and
Mineral Conservation, U. S. S. R.

THE EXTENT OF EXPLORATION OF A MINERAL DEPOSIT PREPARATORY TO ITS COMMERCIAL DEVELOPMENT[1]

by

P.S. Matveyev and A.V. Nikiforov

REVIEWER'S NOTE

A review account of the proper mixture of exploration and evaluation of deposits. Cites mainly examples of over-exploration. Cites the considerable failing to estimate reserves in the "probable" category, in evaluating areas. A general review of common sense in evaluating deposits. Gives a new table for various types of reserves, production plates, etc. to aid in evaluation. The reserve classes are listed by numbers, (designations explained in International Geology Review, v. 2, no. 9, Sept. 1960, p. 741-742). An interesting article.

ABSTRACT

Certain problems of successive conduction of prospecting-exploration work as well as a detailed exploration of various deposits are considered in the paper and it is stated that the correct solution of these problems essentially increases the efficiency of geological exploratory work. The solution of the above problems may be considerably facilitated if the commercial requirements as to the amount and accuracy of estimated ore reserves are quite definite. These requirements however have many shortcomings, e. g., such important factors as the deposit scale and the reserves of category C_2 are not taken into account. A new version of such commercial requirements is suggested which takes into account the scale of the deposits and the prospective reserves (cat. C_2) along with different (A_2, B and C_1) category reserve ratios. --Auth. English summ.

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An analysis of data obtained in detailed reconnaissance, along with numerous engineering-economical reports by planning organizations, leads to some conclusions on the proper sequence and the amount of detail in exploration of mineral deposits prior to turning them over to commercial development. One of the principal, if not the decisive, geologic factors determining the sequence and amount of detail in exploration work, is the extent of the deposit. However, this factor is not always taken into consideration. Very common in geologic exploration are: 1) a detailed surveying of minor deposits without a commercial value; 2) inadequate surveying of commercial deposits; and 3) excessive detailing of some deposits, especially their deeper horizons.

Is it possible to avoid unnecessary expenses of surveying minor deposits? It does not appear possible to dispense with them completely; however, a partial curtailment is both possible and desirable. To achieve that, preliminary exploration should be stepped up. It is also necessary to have it culminated in an engineering-economic evaluation of the deposit. Financing of detailed exploratory work should be done only on the basis of positive indications of commercial value of a deposit, as obtained after an analysis of preliminary data.

Instances are common in current geologic exploration practice when deposits are turned over to commercial exploitation before their detailed exploration and general evaluation have been completed. As a result, considerable difficulties creep into the planning and construction of mining installations, often leading to errors in design. Development of under-explored deposits brings about a lowering of their productivity. When a deposit has been proven larger than anticipated, it becomes necessary to redesign and extend the works, which unavoidably leads to unnecessary expenses.

As an illustration, we cite the following examples.

The Lifudzin tin-ore deposit was discovered in 1940. Originally, it presented a series of isolated locations. As the exploration progressed, the deposit boundaries extended, and by 1957 the Lifudzin deposit was viewed in a different light. Two locations merged into a single ore field, and the vertical extent of commercial mineralization increased considerably.

As the estimated reserves grew, the aspect of the enterprise changed. Originally, the mining complex comprised three independent units, each outfitted with all necessary production equipment. The principal mining works in Unit Three were located at various periods on levels of 814, 744 and 644 m. At the present time, such works are located on the 520 m level. Mine shaft platforms were located accordingly.

After the two units had been merged into a single mine, it became expedient to work it from Unit Three. The annual output of the mine grew progressively. A continual planning and

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[1]Translated from Sovetskaya Geologiya, 1960, no. 3, p. 113-119.

replanning, rebuilding and enlarging — all this has resulted in unnecessary expenditure of time and resources.

This example has the following momentous implications. A correct and economical solution of the mining construction problem is possible only when the deposit is sufficiently known from detailed exploration and when its general extent has been established. Additional expenses, unavoidable in such exploration, will be repaid many times over in savings of the exploitation and construction costs.

A similar situation prevails in the development of other deposits. Along with under-exploration, there often is excessive detailing in the exploration of commercial deposits (particularly their deeper horizons and segments) which are not the primary objects of exploitation. The problem of selecting such segments or horizons for detailed exploration, along with the sequence of work and the amount of detail in exploring individual areas or the deposit as a whole, is extremely critical. Its unsatisfactory solution results in tying up sizable investments for long periods of time by such exploration.

One of the copper-nickel sulfide deposits was explored according to high surveying specifications (categories A_2, B, and C_1), down to 700 or 750 m; and to category C_2, down to 1000 or 1350 m below surface. A positive result of this exploration was the fixing of general extent of the deposit, which considerably facilitated the selection of loading areas and the building of mining installations. However, there hardly was any good reason for exploring the deposit down to 500 to 700 m, by high specification techniques. Ore bodies in those horizons will be worked not earlier than 50 years from now. Consequently, the additional expense of a detailed exploration to these horizons is not justified at the present time.

Bauxite deposits in the North Onyega region, explored in the period 1950 to 1957, consist of a number of isolated areas and locations. The best explored deposit is represented by several ore bodies of various sizes. Only one among them, with the most reserves, is characterized by comparatively favorable mining and hydrogeological conditions. These conditions in other ore bodies are more involved, preventing them from becoming the primary exploitation objects. The development conditions for these other ore bodies are so difficult as to render doubtful their eventual efficient production. Nonetheless, these areas were surveyed in detail. What is more, the exploration of many ore bodies was done in more detail than was the case for the main deposit whose prime importance is not open to any doubt. It is quite obvious that a detailed exploration of areas characterized by such conditions is never expedient.

Among commendable methods is that used in the Plesetsk bauxite area. This deposit, too, is characterized by an involved mining and hydrogeological set-up. For this reason, geologists were quite right in confining themselves to determining its general bauxite potentiality.

Excessive detailing can be justified only when the exploration investment is relatively small and time before the development of a deposit or area is short. Such operations are permissible when a deposit is areally extensive and shallow (some occurrences of silicate-nickel ores, bauxites, etc.).

A good example is the Turgai bauxite deposits, explored in the period 1949 to 1956. They are represented by numerous lenticular bodies. As far as the mining conditions are concerned, these bauxites can be produced by open works. They were explored by pits and boreholes, spaced 50 by 50 m, 50 by 100 m 100 by 100, and 100 by 200 m. As a result, the following categories of reserves were established (in percent of the total): A_2, 22; B, 48; C_1, 30; C_2, none.

Thus, the detailing in exploration of these deposits considerably exceeds the required (A + B at 70 percent as against the required 30 percent). However, in this particular instance, the excess detailing is justified because the deposit is slated for production in the next few years so that some additional expenses for detailed exploration will be compensated for by the reduction in the volume of exploitation surveying prior to mining. It also should be kept in mind that the construction of an alumina plant is contemplated, utilizing the ores of this deposit. A study of the quality of raw material is a decisive factor in the selection of its processing methods. Moreover, the cost of exploratory drilling under given conditions is relatively low.

It follows from what has been said that the sequence of individual stages of exploration, along with the expediencey of a detailed surveying, its location, sequence, and extent, for the deposit as a whole and for its segments, are problems requiring profound and comprehensive study. Ignoring them will lower the efficiency of exploration and render the subsequent exploitation of a deposit more difficult.

At the present time, the degree of detailing in exploration of mineral deposits is determined from a table of recoverable reserves in categories A_2, B, and C_1, necessary for development and for a recovery of the investment in mining establishments (Appendix No. 3 for the Classification of Solid Mineral Reserves).

However, this table has a number of substantial defects and is in need of a revision. Its main shortcoming is that it does not take into account the extent of deposits; more specifically, reserves of category C_2 are not mentioned at all.

RESERVES NECESSARY FOR PLANNING OF AND CAPITAL INVESTMENT IN MINING INSTALLATIONS, DEPENDING ON THE PRODUCTION RATE AND THE RATIO OF RESERVES OF DIFFERENT CATEGORIES

Deposit Group	Annual output of ore, in tons (metric)	Minimum provision of reserves, in years		Proportion of reserves of categories A_2, B, and C_1, in %		
		Categories $A_2 + B + C_1$	Including category C_2	$A_2 + B$	Including A_2	C_2
1. Non-ferrous and rare metals						
1. Deposits of lead, zinc, copper, and nickel:						
a) simple	50-160	8	12	30	5	70
	160-300	15	20	30	5	70
	300-1000	20	35	30	5	70
	Over 1000	30	50	30	5	70
b) compound	50-160	7	12	20	—	80
	160-300	10	20	20	—	80
	300-1000	15	35	20	—	80
	Over 1000	25	50	20	5	80
2. Deposits of cobalt, tin, tungsten, molybdenum, mercury, antimony, gold, arsenic, etc.						
a) simple	50-160	7	10	20	—	80
	160-300	10	20	20	—	80
	300-1000	15	30	20	—	80
	Over 1000	25	45	20	5	80
b) compound	50-160	6	10	5	—	95
	160-300	10	20	5	—	95
	300-1000	15	30	5	—	95
	Over 1000	20	45	5	—	95
c) very complex	50-160	5	10	—	—	100
	160-300	8	20	—	—	100
	300-1000	12	30	—	—	100
	Over 1000	15	45	—	—	100
3. Deposits of aluminum raw material						
A. Bauxites						
a) simple	160-300	20	30	50	10	50
	300-1000	25	40	50	10	50
	Over 1000	30	50	50	10	50
b) compound	160-300	15	30	30	5	70
	300-1000	20	40	30	5	70
	Over 1000	25	50	30	5	70
B. Non-bauxitic raw material (nepheline and alunite rocks). .	1000-3000	25	40	70	10	30
	3000-5000	35	50	70	10	30
	Over 5000	45	60	70	10	30

Explanatory notes to the Table:

1. Simple deposits are those represented by large ore bodies of a simple form (tabular, stock-like), also consistent placers. The distribution of simple deposits is relatively uniform. Compound deposits are made up of complex ore bodies (lenses, weins, irregularly shaped deposits), and inconsistent and pocket-like placers. Their mineral content is uneven. Very complex deposits are even more involved (veins, columnar bodies, small enechelon veinlets, and pockets) with extremely uneven distribution of ore minerals.

2. When a deposit is the component of a basin or a group of deposits, the minimum reserve provision may be somewhat lower.

3. Should any difficulty arise in estimating the production rate of the contemplated establishment, the Gosplan of the Republic or a leading planning organization should be consulted.

4. Any deviation from this table should be specified in the report on reserves.

5. This table has been compiled on the basis of current demands on the several reserve categories; it is a manual for prospecting and the transfer of a deposit to industrial development. The productive life and production rate of a deposit may be specified more precisely in planning.

This means that slated for commercial development are deposits not quite explored, whose extent is unknown. By the same token, reserves of numerous minor deposits without even a remote commercial value are listed among those recoverable.

Although the Instruction for the Transfer of Mineral Deposits to Industry (Appendix 2) states that "along with exploration of the main area to be transferred to industrial development, the general extent of a deposit or else its total reserves of category C_2 should be estimated," such reserves often are not calculated and, as a rule, annual work schedules of geological administrations carry no specifications for a increase in category C_2 reserves.

It should be noted that a well-substantiated estimate of category C_2 reserves calls for a more profound geological analysis than that of higher categories. In a number of instances, this is the reason for the geologists' reluctance to estimate such reserves. It follows that the degree of readiness of a deposit for commercial development is determined by category C_2 reserves along with those of categories A_2, B, and C_1.

On the basis of experience in planning of mining installation for non-ferrous metals, it is deemed expedient to modify Appendix No. 3 of the present classification of solid mineral reserves to read as follows (for non-ferrous and rare mineral deposits).

In the table, deposits are grouped according to their complexity. The principle of grouping is the same as in the now operative table and does not require any special explanation.

The minimum extent of a deposit (its proven reserves) slated for commercial development is limited by its future production rate and the length of its productive life. These data should be listed in the table of the deposit extents, rather than the now given figures of minimum reserves. This is because the reserves required are determined in many instances not by the extent of the deposit but by the production rate and the amortization time (productive life of a deposit). The production rate of a future establishment depends in turn on its extent, the mining-engineering conditions of its development, the demand for this particular raw material in the country or in a given area, etc. In other words, the production rate is determined either by the extent of a deposit or by other factors. Thus, the projected production rate of many mining plants is determined by mining-engineering possibilities rather than by the extent of their associated deposits. On the other hand, larger reserves in such deposits allow a considerable stepping up of the production rate.

Consequently, since the production rate of an enterprise is determined not by the magnitude of the deposit, alone, it is sufficient to explore in detail only that portion of its reserves which will keep the enterprise working for a definite time necessary for its amortization.

For the same reason, the proportion of reserves of categories $A_2 + B + C_1$ and those of category C_2 is best expressed in these two parameters. The production rate scale adopted in the table has been established on the basis of type designs for non-ferrous metal ore mines, now being drawn by a number of planning organizations.

The productive life of deposits, on the basis of reserve categories $A_2 + B + C_1$ and taking into account category C_2, is determined from the planning data and from the experience in non-ferrous metallurgy. The total life expectancy increases with the extent of reserves of categories $A_2 + B + C_1$, but more so with the growth in the category C_2 reserves. It is quite obvious, that the larger the plant the longer must be the productive life of its raw material base. However, a detailed prospecting of all reserves necessary to keep the plant in operation for the entire amortization period may freeze up a considerable investment in exploration work. It appears, then, that it is expedient to explore some of the reserves for category C_2.

The proportion of reserve categories A_2, B, and C_1 is determined depending on the complexity of a deposit. The proportion of categories A_2 + B in this table has been reduced somewhat as compared with the operative classification. This is because, under the present conditions, the category C_2 reserves, too, are fairly well substantiated. Reserves of category A_2 are left standing only when extensive and complex engineering studies are required. This pertains mostly to those deposits slated as bases for major industrial enterprises.

It is believed that basic principles of the reserve relationship, adopted in compiling this table, reflect better the demands on industry and the extent of exploration than the present classification does.

At the same time, the proposed table of proportion for reserves of various categories can be used in a preliminary evaluation of deposits under exploration. The product of productive life by the contemplated production rate will give the minimum reserves of a commercial deposit.

THE EVOLUTION OF SALINE REGIMEN IN UPPER CARBONIFEROUS AND LOWER PERMIAN BASINS OF TATARIA AND ADJACENT REGIONS[1]

by

F.S. Mal'kovskiy

REVIEWER'S NOTE

Contains a faunal range chart that may be of considerable interest.

ABSTRACT

The tectonic development and salinity variations during deposition are traced for the Upper Carboniferous and Lower Permian of Tataria, based on faunal (primarily foraminifera), lithologic, and petrographic studies. --M. Russell

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This paper discusses the results of a study carried on for the last twenty years by the Tatneftegazrazvedka Trust. Having studied the fauna in rocks ranging from Lower Carboniferous to the Ufa formation, as well as lithologic and petrographic data from hundreds of structural boreholes, along with their electric logs, we have described the Upper Carboniferous aspect of beds from the base of the Triticites horizon to the top of the Schwagerina beds--the Uralian stage, as we understand it [2, 3].

Above the top of the Uralian stage an abrupt change in lithology and fauna takes place. The Tastub beds of Tatariya and adjacent regions are not marine carbonates, i. e., deposits of a shallow sea (Triticites, Pseudofusulina, and Schwagerina beds of the D. M. Rauzer-Chernousova chart), but lagunal-marine carbonate-sulfate formations: blue anhydrites, light-gray gypsum with dolomite intercalations, less commonly limestones (usually pelitomorphic to fine-grained, undoubtedly primary), denser than dolomites of the Triticites, Pseudofusulina, and Schwagerina beds, and, what is more important, free of those fossils which determine their Upper Carboniferous status--Triticites, Daixina, Rugofusulina, Quasifusulina, Fusulinella, Fusiella, Carboniferous Pseudofusulina, simple to composite corals, brachiopods, and echinoids.

The Tastub and the overlying Sterlitamak horizons (see figure 1) witness the appearance of a new faunal assemblage: new species of Parastafella, small foraminifera, and simple, composite, and massive corals [2, 3].

It also should be noted that definite evidence of an erosion, perhaps local (breccias, conglomerates, and gravel beds), is present at the Uralian-Sakmarian boundary (areas Bazaro-Matak, Bugul'ma, Karmalinsk, Kovali, Chuninsk, Sulinsk, Cherdaklinsk, Yukhmachinsk, Yanchikovsk, etc.).

Such abrupt changes in the aspect of rocks and the composition of their fossil assemblages can be explained by tectonic causes, such as a fairly sharp uplift of the entire east of the Russian platform. This is readily correlated with the known data from the Urals and Ural region. For instance, thick breccias and conglomerates at the base of the Sakmarian stage are known from the Simsk plant area, in the Aktyuba area, and elsewhere, as well as from the Pak-Khoy range area.

Far from rejecting the idea of an evolution of the saline regimen in both the Upper and Lower Carboniferous basins of Tataria, we do believe, nonetheless, that this evolution was not the only reason for the above-mentioned abrupt change in Tastub facies. The main reason is a tectonic one.

This is why we cannot agree with I. N. Tikhvinskiy [6] that an evolution of the saline regimen in Uralian time (Assel, according to I. N. Tikhvinskiy) led to an abrupt change in facies at the Uralian-Sakmarian boundary. It is not clear on what ground I. N. Tikhvinskiy differentiates the Uralian stage into upper and lower members.

There is evidence to the effect that regularities in sedimentation, undoubtedly once present in the Uralian basin of Tatariya, have been camouflaged to a considerable extent by processes of dolomitization and recrystallization. For this reason, students of Tatariya [1, 4, 5] have been unable to identify Uralian horizons, let alone members. We have designated Uralian horizons by their faunal characteristics, alone [2, 3].

Evolution of the saline regimen proceeded in both the Upper and Lower Carboniferous. Thus, marine waters become more saline during the

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[1]Translated from Sovetskaya Geologiya, 1960, no. 3, p. 120-121.

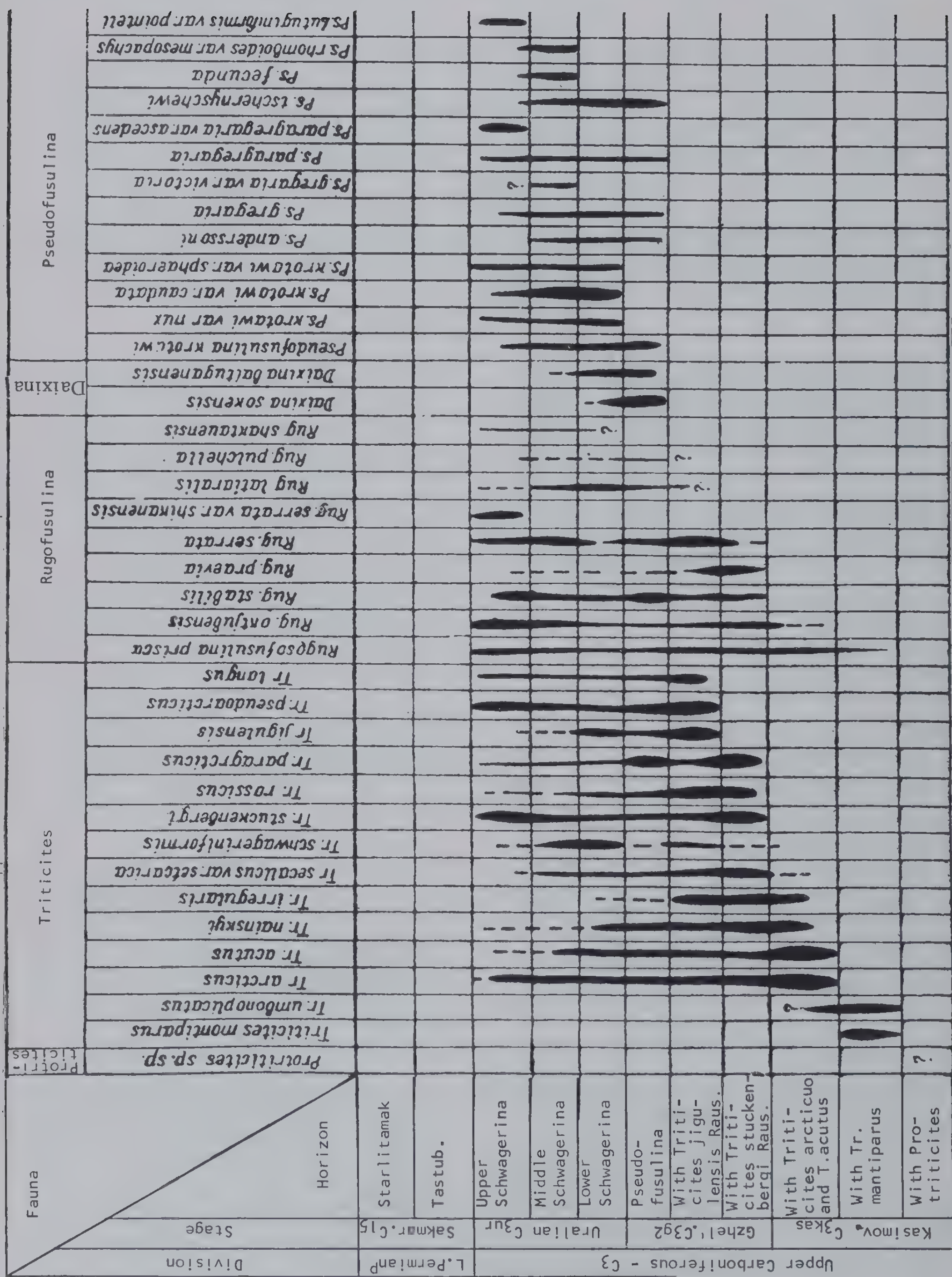


FIGURE 1. Distribution of fauna of foraminifera, corals, brachiopods, and gastropods in Upper Carboniferous and Lower Permian periods in Tataria

FIGURE 1. Distribution of fauna of foraminifera, corals, brachiopods, and gastropods in Upper Carboniferous and Lower Permian periods in Tataria (Continued)

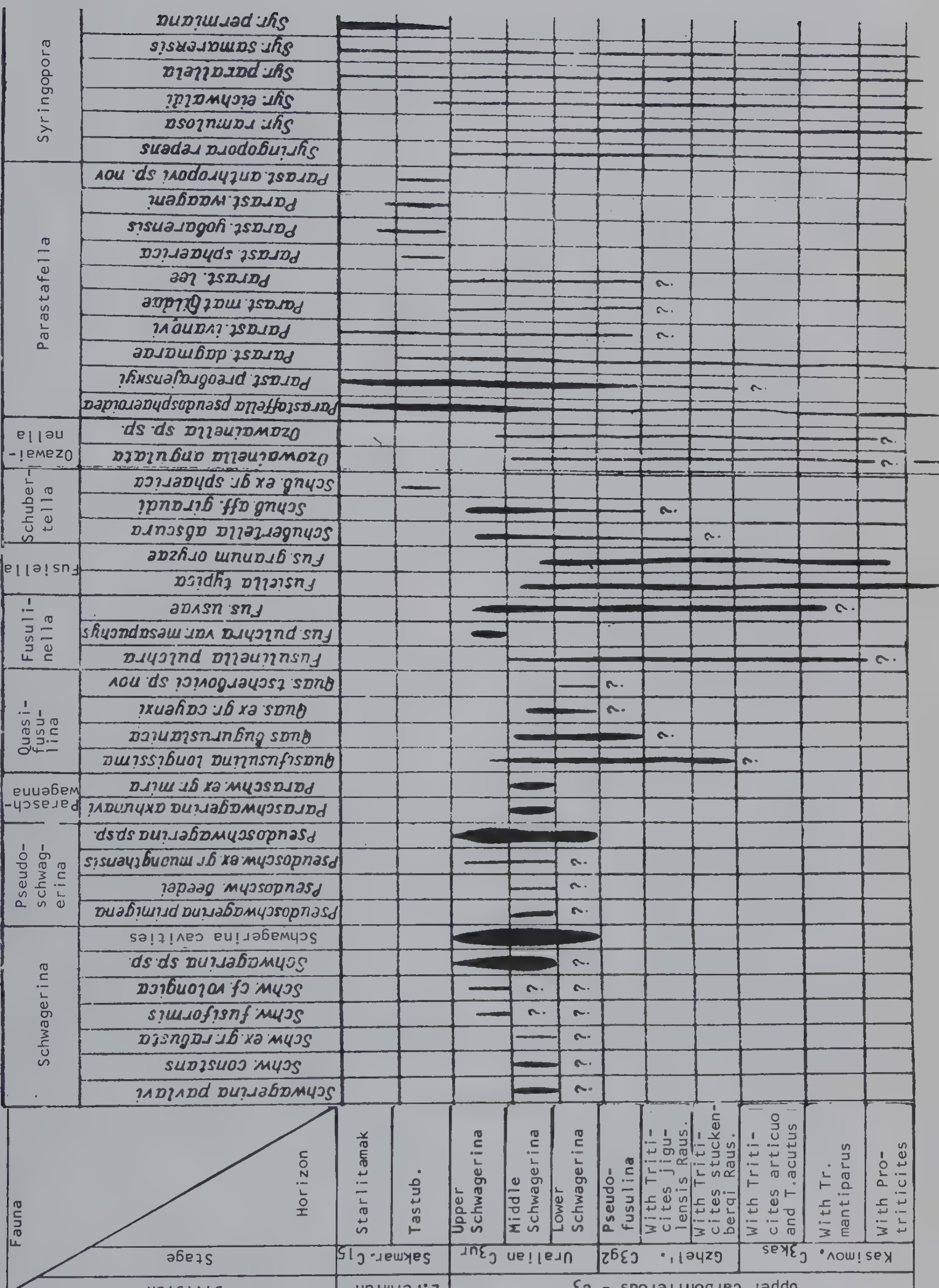
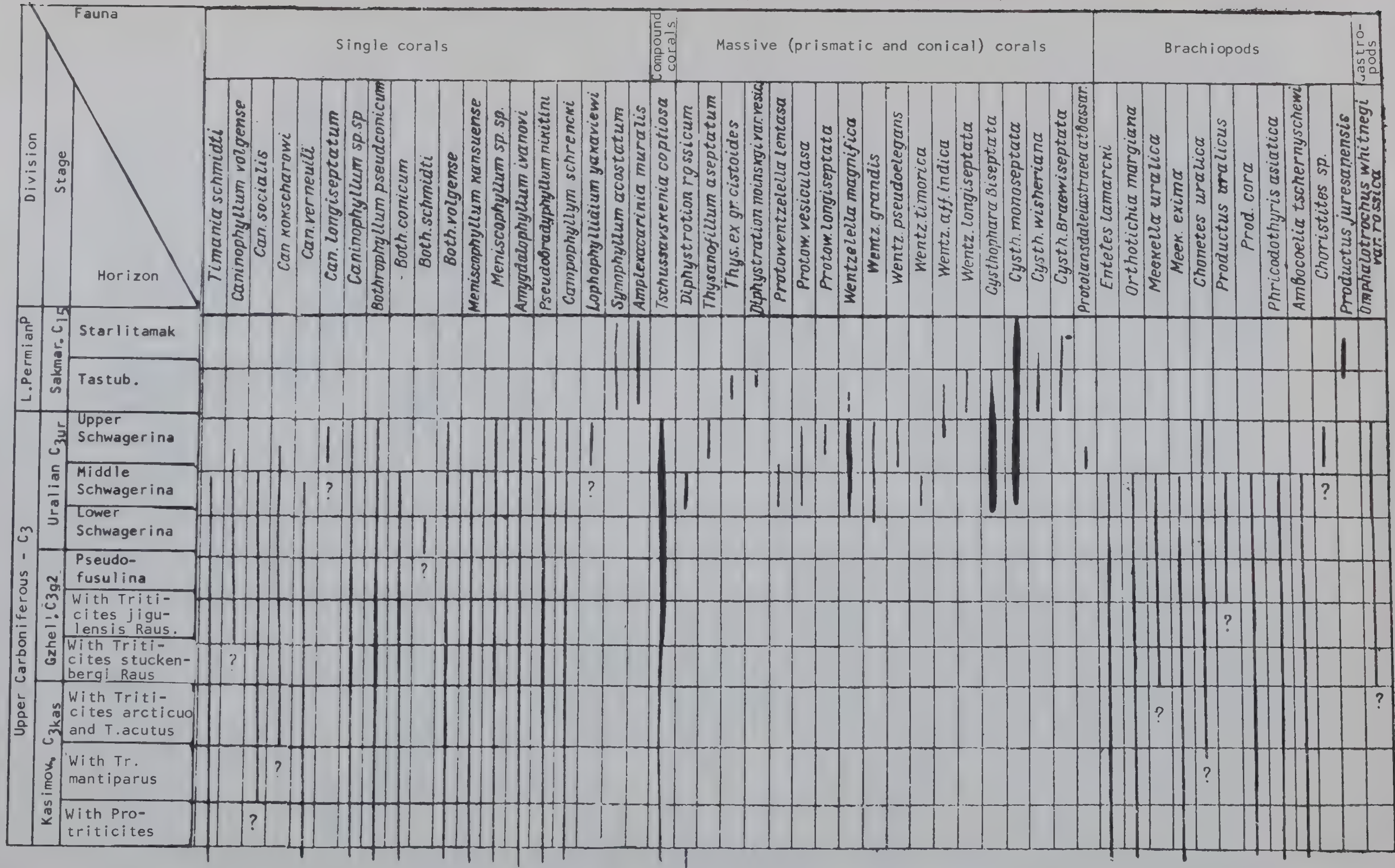


FIGURE 1. Distribution of fauna of foraminifera, corals, brachiopods, and gastropods in Upper Carboniferous and Lower Permian periods in Tataria (Concluded)



Upper Carboniferous (close of Kasimov, Gzhelian, and Uralian times). This is what brought about the formation of sulfate intercalations in the uppermost intervals of those stages.

Toward the close of the Uralian, the salinity became somewhat higher, with a resulting deposition of a sulfate bed (mostly anhydrite) in some areas of Tatariya. Similar beds, somewhat thinner, are present at the top of the Kasimov stage, and less commonly at the top of the Gzhelian stage. It also should be noted that these beds are overlain, as a rule, by carbonate rocks (chiefly dolomites) with cavities left behind by leached-out Schwagerina shells, less commonly with the shells themselves, including those of Triticites and Rugofusulina.

It is clear even from Fig. 4 in the above-named paper by I. N. Tikhvinskiy, who operates with generic and even type faunal names (inadmissible in itself), that, in his own works, "these salinity indicators" disappear on the whole above the Uralian stage. If he had cited similar data for the Kasimov and Gzhelian stages, this phenomenon would have been even more distinctive. It appears from the right hand portion of Fig. 4, "Curves of the change in relative salinity of the Assel-Sakmarian seawater", that these curves never reached the level of "sulfate rocks with intercalations of barren dolomites", in Assel time; that did not take place until the Tastub time.

The evolution of Lower Permian basin was retrograde, with a decrease in the salinity of waters in the Tastub and Sterlitamak basins. This is suggested by the smaller number of sulfate beds, and their thinning down, going from the base of the Tastub horizon to the top of the Sterlitamak. As in the Upper Carboniferous, this was caused by tectonic phenomena. The Sakmarian basin was getting deeper, gradually but steadily, in sympathy with a subsidence in the east of the Russian platform, which is corroborated by both lithology and fauna.

In the beginning of Artinskian time, Tataria was uplifted again as witness the presence of chiefly sulfate rocks of the Irginsk-Sarginsk sequence resting everywhere on eroded Sakmarian limestones. This uplift was more intensive then the post-Uralian one; as a result of it, most of Tatariya stood dry. The uplift recurred for the third time during the Iren'sk Kungurian time. It is not an accident that Iren'sk beds, like the Tastub and Lower Artinskian, are made up chiefly of sulfate deposits. It follows that the abrupt change in the evolution of the saline regimen, heralding the onset of Permian period, did not occur until the beginning of Tastub time.

REFERENCES

1. Veryasov, M. P., Nizhnepermskiye otlozheniya TASSR. [LOWER PERMIAN DEPOSITS OF THE TATAR SSR]: Uch. Zap. KGU, vol. 116, book 14, 1956.

2. Mal'kovskiy, F. S., Itogi izucheniya verkhnepaleozoyskoy fauny Tatarii v svyazi s problemoy granitsy karbona i permi. [RESULTS OF THE STUDY OF UPPER PALEOZOIC FAUNA IN RELATION TO THE PROBLEM OF THE BORDER BETWEEN THE CARBONIFEROUS AND PERMIAN OF TATARIYA]: Tatneft', No. 11, 1958.

3. Mal'kovskiy, F. S., Paleontologicheskaya kharakteristika ural'skogo yarusa Tatarii. [PALEONTOLOGIC CHARACTERISTICS OF THE URAL STAGE OF TATARIYA]: Izv. KFAN SSSR, ser. geol., No. 7, 1959.

4. Miropol'skiy, L. M., Topogeokhimicheskoye issledovaniye permskikh otlozheniy v Tatarii. [TOPO-GEOCHEMICAL INVESTIGATION OF THE PERMIAN DEPOSITS OF TATARIYA]: Izd, Akademiya Nauk SSSR, 1956.

5. Teodorovich, G. I., Karbonatnyye fatsii nizhney permi - verkhnego karbona Uralo-Volzhskoy oblasti. [CARBONIFEROUS FACIES OF THE LOWER PERMIAN - UPPER CARBONIFEROUS OF THE URALS-VOLGA DISTRICT]: Izd. MOIP, 1949.

6. Tikhvinskiy, I. N., Ob evolyutsii solevogo rezhima assel'sko-sakmarskogo morya yuga Tatarii i prilegayushchikh rayonov. [THE EVOLUTION OF THE SALT PROCESS OF THE ASSEL'SK-SAKMARSK SEA OF SOUTHERN TATARIYA AND THE ADJACENT REGIONS]: Dokl. Akad. Nauk SSSR, vol. 126, No. 5, 1959.

The Tatneft'razvedka Trust

TYPES OF FOLDING OBSERVED IN COAL DEPOSITS OF THE SOUTH URALIAN BASIN[1]

by

P.I. Il'in

REVIEWER'S NOTE

Describes and explains probable origin of the coal diapir structures in the Uralian basin. Very interesting little paper.

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The south Uralian brown coal basin is located in the southern part of the Bashkirian A. S. S. R. and in the northern part of the Orenburgskaya Oblast', in western foothills of the South Urals. In recent years, dozens of Tertiary brown-coal deposits have been reconnoitered here. They have much in common, stratigraphically, tectonically, and lithologically, although each of them was formed independently. Such a local distribution of deposits is explained by their formation in small depressions. In the north of the basin, they represent karst hollows in gypsums or else sagged segments at the crests of salt domes. These latter structures originated in a flow of Upper Permian salt, anhydrites, and gypsum, below a thin Upper Permian clastic sequence or else directly underlying Mesozoic-Cenozoic sediments.

As a rule, these depressions are not large, seldom reaching 20 or 25 km^2, with a depth of 200 or 300 m. The area of their coal deposits is even smaller, not over 10 to 15 km^2. These depressions are usually oval, rarely round, such as the Babayevsk deposit. The oval structures usually have a Uralian trend (north-south), although some of them (Yermolayevo-Mayachnoye) trend latitudinally.

The rock sequence in these troughs is monotonous, with Rhaetic-Liassic beds of the so-called Surakay formation resting erosionally on a Permian basement. Their lower part is represented by conglomerates of small motley argillaceous pebbles (disintegration products of Permian rocks); the upper part is represented by drab-gray sands and shales. This section is 20 - 110 m thick.

Resting on the Rhaetic-Liassic, with an erosional break and angular unconformity, are Middle Jurassic gray sandy shales and strongly argillaceous sandstones with plant remains and occasional beds of brown coal. The Middle Jurassic interval is over 100 m thick.

Preserved at two points (Sargul Mt. and village Nikitino, Orenburg Oblast') are Upper Jurassic marine deposits resting on the Middle Jurassic. They consist of green fine-grained sands and sandstones and non-calcareous shales, with phosphate nodules in some horizons. Total thickness of the Upper Jurassic is 60 m.

Above that, there are Cretaceous marine sediments represented at their base by green-gray quartz-glauconitic argillaceous sands and gray shales and overlain by light-gray chalky shales with well-polished siliceous pebbles. Cretaceous deposits usually are only 25 m thick, attaining occasionally 70 m.

Tertiary deposits, resting either on Cretaceous or directly on older rocks, too, are distributed in small areas. Their lower division (Oligocene-Miocene) is represented usually by light-gray fine-grained sands and silty mudstones. Most coal deposits in this sequence are represented by lenticular beds from 1 to 10 m thick. The total thickness of this interval is about 100 m.

Occurring above that, with a gradual contact, are the so-called lower Miocene coal measures, with brown coal at their base and gray claystones with coal layers above. The coal section attains 40 or 50 m and more in individual deposits. The total thickness of this formation is 50 or 60 m.

Lying above the Miocene there are Upper Neogene (Pliocene) sediments, represented by a continental facies in coal deposits and by a marine (Akchagyl) formation in the valleys of large rivers. The continental beds are represented by drab to drab-red sandy clays and coarse-grained sands with siliceous pebbles. Only isolated structures in the central part of Pliocene sequence exhibit layers of gray clays with carbonaceous plant remains and even coal lenses (Khabarovsk deposit). The Pliocene is usually between 30 and 50 m thick, with 270 m in the Khabarovsk deposit.

All these rocks are covered by a nearly unbroken mantle of Quaternary alluvium--drab loams and clays, 15 to 20 m thick.

It has been observed as a general rule that continental deposits change going from the periphery to the center of trough; on the periphery,

[1]Translated from Sovetskaya Geologiya, 1960, no. 3, p. 130-135.

they are represented by coarse material which changes gradually to fine clays in the center. Even the ash content increases two to three times, going away from the center. Marine sediments in depressions do not exhibit this regularity.

It should be noted that sediments of one to several stratigraphic subdivisions are missing in individual coal-bearing structures, as a rule. This is due to the cessation of subsidence in these troughs, during the corresponding periods. In addition, rocks of one stratigraphic horizon in a trough are eccentric with relation to another horizon. This suggests an uneven sinking of these troughs.

are better understood if we remember that the basement and slopes of these troughs are made up of consolidated hard rocks--shales and sandstones--while the troughs themselves are filled up with plastic and unconsolidated deposits, such as clays, coals and sands. Stresses during the formation of troughs were relieved by rifts in rigid rocks and chiefly by plication in the unconsolidated rocks.

Within the troughs, the beds are saucer-shaped, with steepest dips observed along their southwest slopes. These saucers are eccentric, commonly tilted (Fig. 1). Their rigid basement is commonly broken up by a single fault passing along the southwest side of the trough. Individual beds wedge out toward the periphery, thus suggesting that the troughs were formed by sinking.

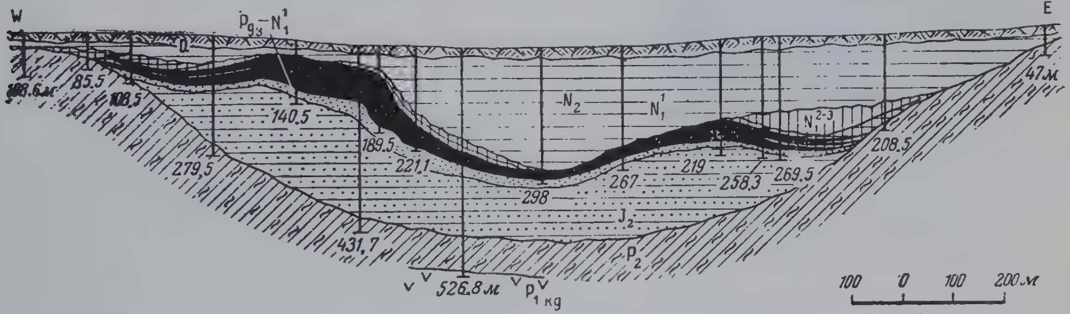

FIGURE 1. Cross section across the strike of rocks in the Khabarovsk deposit.

Black = coal

The presence of Rhaetic-Liassic and younger sediments in the troughs, together with their absence in other areas of the region and the local occurrence of many horizons, suggests that these structures were initiated in the Rhaetic-Liassic.

Because of the newly initiated open-pit method of coal production, accompanied by an intensification of exploratory work, it has become possible to late to gather data bearing on the tectonics of these deposits. The peculiar features of tectonic forms observed in these coal deposits

The coal measures exhibit two types of folding: warping folds, developed along the troughs' sides; and flow folds (flow structures?), mostly within the coal intervals.

In their size and origin, the warping folds can be assigned to second order folds. They are concentrated mostly along the southwest side of structures, in the region of highest stresses, in bends. Their origin is connected with

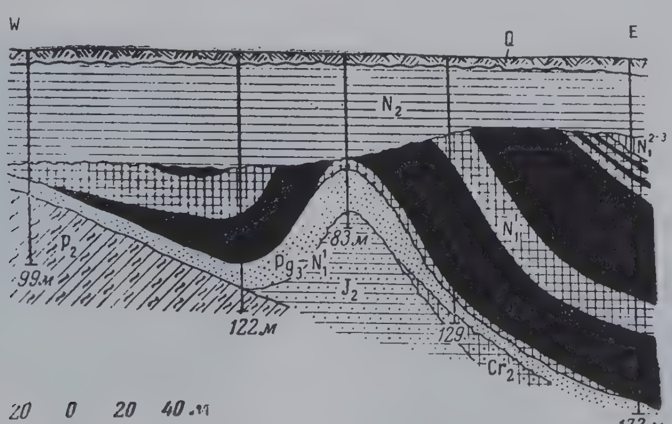

FIGURE 2. Buckling folds (Khabarovsk deposit).

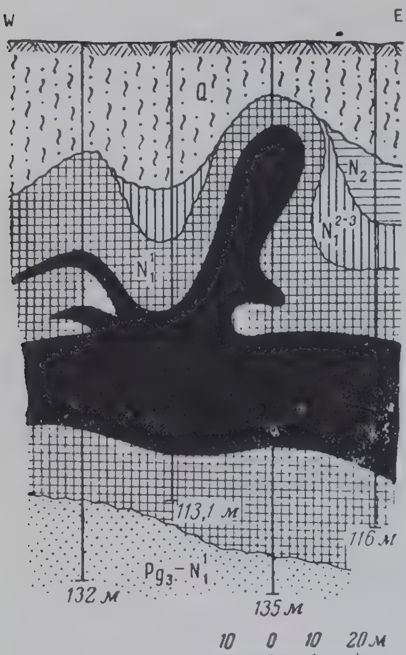

FIGURE 3. Coal diapir by the west side of the Tyul'gansk deposit.

compression brought about by synclinal folding. These folds are symmetrical or else somewhat tilted outward. They are 70 m high by more then 100 m wide at the base. Their length is different deposits. Warping folds have been observed in the Khabarovsk (Fig. 2), Tyul'gansk, Mayachnyy, and other deposits.

The flow folds arise within a coal body and may be assigned to third order folds. They are expressed in coal diapirs of various forms (Figs. 3, 4, 5), most commonly as dikes, domes, and cones, lined-up chain-like along the west wide of a coal deposit. These diapirs are 60 m high, 0. 5 - 50 m wide, forming a chain up to 500 m long and longer. They are seldom detectable in boreholes and are seen in better detail in coal mine faces of the Babayevsk, Mayachnyy, and Tyul'gansk deposits. As pointed out before, these folds have not been penetrated by boreholes in other parts of deposits; nor has any mining been done there.

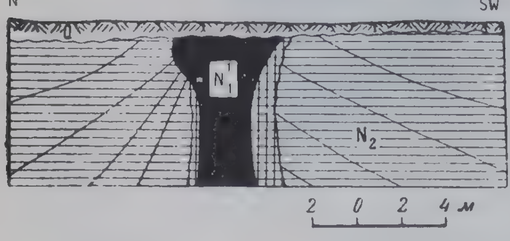

FIGURE 4. Coal diapir in the Mayachnyy deposit (east wall of the exit trench).

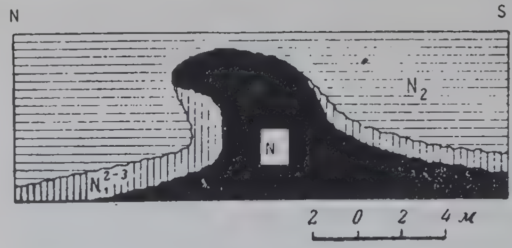

FIGURE 5. Coal diapir in the Babayevsk deposit (west wall of the North Yermolayevsk section).

Flow folds may have been formed in the squeezing of soft coal during the compression folding.

Also assigned to flow folds--of a different order--may be the considerable local enlargement in coal beds, such as those observed at the southwest margin of the Tyul'gansk deposit (Fig. 6). Such formations could have been produced by static load under favorable conditions prevailing there. In that part of the deposit, coal occurs near the surface, while it plunges several tens of meters deeper at the opposite side. A differential pressure thus arises in the coal body. Considering the high moisture content in coal (over 50%), it is quite conceivable that a plastic flow might displace some coal from the higher to the lower pressure areas. Such a flow would also be promoted by the low volume weight of coal (about one) and a heavier (about two) weight of the overload, as well as the immense mass (20 - 30 meters and more) of coal in the deposits.

These facts suggest that the blown-up segments of coal deposits in their elevated parts, as observed in a number of deposits of the basin (Tyul'gansk, Krivlensk, etc.) are related to coal flow rather than primary forms of its deposition.

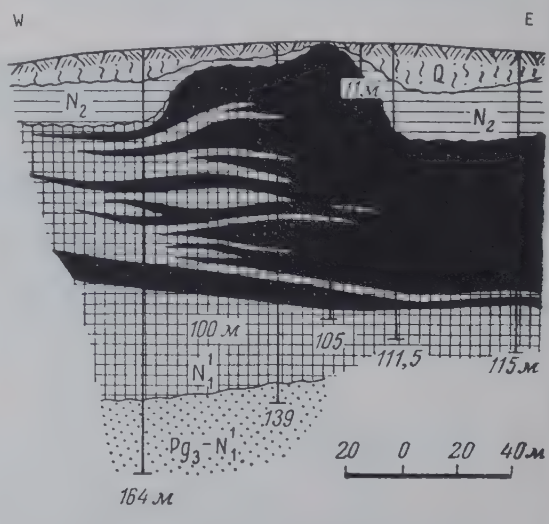

FIGURE 6. Tectonic widening of the coal measure in the Tyul'gansk deposit.

REVIEW OF O.L. EYNOR'S BOOK."STUDY IN CARBONIFEROUS STRATIGRAPHY ON THE EAST MARGIN OF THE VOLGA-URAL OIL REGION"[1]

by

G.I. Teodorovich [2]

REVIEWER'S NOTE

Somewhat biased review of one of the important new works on Carboniferous stratigraphy. In a section of the U.S.S.R. containing very fossiliferous beds, the fundamental problems of correlation are discussed in detail. The book contains very detailed stratigraphic sections with detailed faunal summaries of each unit measured.

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This book presents the results of analysis of data on the Lower and Middle Carboniferous, gathered in 1953 by O.L. Eynor and his collaborators on the west slope of the South Urals.

The book consists of an introduction, a brief survey of work on the stratigraphy of the Lower and Middle Carboniferous, chiefly in the European U.S.S.R., and two parts: Part I - Stratigraphic Outline, and Part II - Description of Carboniferous Sections in Mountainous Bashkiria. Chapter One of the stratigraphic outline, dealing with the Lower Carboniferous, gives brief information on the Tournaisian of this area, and detailed data on the Visean which includes most of the Namurian. Visean (according to O.L. Eynor) horizons are taken up, one by one: A - O; A - I; A - II; A - III; A - IV; B - I + II; and B - III. Discussed in Chapter Two are the structure and fauna of Bashkirian horizons of the Urals, as designated by other authors, in sections of the Urals, Donbas, and Volga-Ural region, as well as other areas of the U.S.S.R., in part; the Lower and Middle Carboniferous boundary and the problem of the Namurian stage in the U.S.S.R.; and the composition and fauna of the Moscovian stage in mountainous Bashkiriya.

Of most interest are those chapters describing, one by one, Visean horizons in the O.L. Eynor interpretation; and the Bashkirian stage in which he includes the upper part of the Namurian, namely Namurian B. These chapters contain very valuable and extensive rosters of faunas of foraminifera, brachiopods, and corals, given for each horizon, individually.

The correlation of Bashkirian horizons of O. L. Eynor with those previously described by other authors is incorrect, while the boundary between the Lower and Middle Carboniferous, and especially the problem of the Namurian in the U.S.S.R., are treated from a biased point of view.

Part II of this work, dealing with detailed descriptions of the Carboniferous sections observed, with their faunas identifed for each bed, unquestionably is of great interest. It should be noted that there is a tendency of late not to publish complete descriptions of sections under study, with faunas given for each bed. A composite section is often given, instead. This prevents a field check-up of the authors' ideas. This is not true of the O.L. Eynor book.

Along with these merits, O.L. Eynor's book has some shortcomings, three principal ones: the tracing of the Lower Carboniferous–Upper Carboniferous boundary; the correlation of upper horizons of the Lower Carboniferous and Bashkirian horizons of mountainous Bashkiria, according to Eynor, with horizons of other authors; and the problem of the Namurian.

In disregard of the 1951 unified stratigraphic scheme, O.L. Eynor includes the Protvinsk horizon into the Serpukhov substage and assigns all these deposits to the Visean. The fact is that stratigraphic unity of the entire Serpukhov sequence has long since been known; however, as shown by L.S. Librovich [1] and this author after him [11], the entire Serpukhov formation belongs to the lower Namurian, only. For this reason, the "Serpukhov stage" proposed by S. N. Nikitin [2] in 1890 cannot be substituted for the earlier designated Namurian stage (Belgium, 1883) accepted for international usage by the 1927 Heerlen Congress.

O.L. Eynor [15, page 43] believes that the "Martinia horizon" is strictly consistent at the base of the Bashkirian stage. However, it was shown as early as 1954 that Martinias are not associated with a blanket horizon but occur in disjointed banks on different stratigraphic levels of the upper Namurian (Namurian B of the Heerlen Congress) and the lower Bashkirian substage. Because of that, the identification of horizons by a "Martinia horizon" or by the relationship to it is not reliable. This horizon is often missing on its proper stratigraphic level, even in O.L. Eynor's own cross-sections.

O.L. Eynor [14, 15] subdivides the Bashkirian stage into four horizons, the lower of which, C_2^{I}-I, he calls the Yakh'insk and gives a list

[1]Translated from Sovetskaya Geologiya, 1960, no. 3, p. 136-140. The book reviewed was published by Gostoptekhizdat, 1958. [See Ref.15, p.943.]

[2]Ministry of Geology and Mineral Conservation, Academy of Sciences of the U.S.S.R.

of its fauna. However, an analysis of his own data shows that Bashkirian choristates and Upper Carboniferous forminifera are present only in the upper part of his horizon C_2^1 - I. It appears therefore that the lower part of this horizon should be more properly assigned to the top of the Lower Carboniferous, namely the Namurian, with its upper part assigned to the base of the Bashkirian stage, as we have done in our 1956-1957 works [12, 13] by designating corresponding horizons C_1^{3-2b} and C_2^{1-1}. With regard to corals, O.L. Eynor believes that "most important . . . is the appearance here of Upper Paleozoic Lytvophyllum" (p. 44), although representatives of this genus, as well as Bashkirian choristates, are known in the South Urals only from deposits corresponding to the upper part of the so-called Yakh'insk horizon.

Thus the Yakh'insk horizon of O.L. Eynor consists of two non-contemporaneous intervals: the lower, corresponding to the top of the Lower Carboniferous (Namurian B) and carrying a Lower Carboniferous faunal assemblage, and the upper interval — which we have designated as horizon C_2^{1-1} — belonging to the base of the Middle Carboniferous.

O.L. Eynor states that he "has found choristates . . . also considerably below the Martinia horizon which appears to occur at the base of horizon C_2^{1-1} of the new classification by G.I. Teodorovich" [15, p. 44]. However, the view that numerous Martinias are associated in the South Urals with a single horizon is without justification [11]. This is also true of O.L. Eynor's opinion that choristates occur below the "Martinias horizon" at the base of our C_2^{1-1} horizon.

The Akavassk C_2^1 - II horizon of O.L. Eynor corresponds to two horizons of our 1956 classification [12, 13]: C_2^{1-2} and C_2^{1-3}. Indeed, the Akavassk horizon is older than the "river Belaya horizon" C_2^1 - III of O.L. Eynor, which corresponds to our horizon C_2^{1-4}. However, applying the names Akvassk and river Belaya to stratigraphic horizons of different ages is unfortunate because the hamlet of Akvas itself is located on the Belaya river, and the type locality of the river Belaya horizon is located at the same river, not far from Akvas. It should be noted that here our horizons C_2^{1-1}, C_2^{1-2}, and C_2^{1-3}, constitute the lower Bashkirian substage.

O.L. Eynor's horizon C_2^1 - III, or the river Belaya horizon, as well as the lower part of his C_2^1 - IV, the "Uklukainsk", horizon were studied by us in detail, much earlier, in an unbroken section of the upper half of the Bashkirian stage and of the entire Moscovian stage, along river Zilim, near village Tashasta.

O.L. Eynor's objection to my statement that he included the base of the Moscovian stage into his horizon C_2^1 - IV is without merit; he, himself, admits that much in another place. As shown by a careful bed by bed study of fauna, the upper - and the smaller - interval of 1957 C_2^{1-5} horizon [12], too, belongs to the base of the Moscovian, namely the lower part of the Verya horizon (judging by the foraminifera and choristates assemblage). The Bashkirian-Moscovian boundary passes, as we have noted before [9], between horizons C_2 - 3 and C_2 - 4a of our 1935 classification [8]. Thus, our horizon C_2^{1-4} and the lower and middle parts of the 1956 [13] C_2^{1-5} horizons (except for beds "transitional to the Vereya") comprise the upper Bashkirian substage, being correlative with the upper Choristites horizon of the S.V. Semikhatova [7] Bashkirian horizon. O.L. Eynor's reference to the undoubtedly Moscovian age of deposits carrying Ozawainella ex gr. O. angulata Col., O. cf. rhomboidalis Putr., and Choristites cf. e. holtedahli Frcks. are also known from horizon C_2^{1-4} of river Zilim, i.e., throughout the upper Bashkirian substage [12]. Moreover, Choristites cf. holtedahli, being a thin-costate species, does not belong to the Choristites priscus Eichw. group, as O.L. Eynor believes.

In his 1958 work [15], O.L. Eynor refers on numerous occasions to our old 1945 generalized differentiation of the Bashkirian stage [10], despite the fact that we proposed in 1956 [13] its new differentiation into five horizons. In so doing, he is like some others advocates of elimination of the Namurian stage from the U.S.S.R. stratigraphic scale who correlate their new classifications with our old ones (1935 and 1945). Of course, this is one way to prove some "advantages" of their method; this, however, is not the right way to approach the subject.

O.L. Eynor distorts our 1935 and 1945 scales [8, 9, 10] and confuses the issue by incorrectly correlating our 1935 subdivisions with our 1956 horizons [13], as well as with his own 1955 - 1958 horizons of the Bashkirian stage [14, 15]. He disputes the thickness of our 1945 lower Bashkirian horizon C_2^{1a} on the assumption that it includes all of the 1936 transitional beds, although it includes, in fact, only their upper part. This erroneous correlation is the basis of his subsequent arguments.

O.L. Eynor's criticism of the middle Bashkirian horizon of our 1945 classification is unfounded because in 1956 we split this horizon [13] into two independent ones: C_2^{1-3} and C_2^{1-4} whose contact coincides with that between the lower and upper substages of the Bashkirian stage; it was specified that first Profusulinella appear at the base of horizon C_2^{1-4} [13]. It is clear, then, that O.L. Eynor misleads the reader when he writes, in 1958, that "the appearance of Profusulinella in the middle Bashkirian horizon contradicts its correlation with horizon C_2^{1-3} where they are missing" [15, p.56]. Such a statement causes nothing but confusion.

O.L. Eynor states on p. 71 [15], "after new data on the vertical distribution of Choristites and Pseudostafellas had been published (Eynor, 1955), G.I. Teodorovich informed us that Choristites appeared before Pseudostafellas at the base of the Bashkirian (Teodorovich, Grozdilova, Lebedeva, 1956; Teodorovich, 1957)." This statement is misleading inasmuch as a number of Choristites were collected from lower Bashkirian horizons, during the 1954 field work, and identified by S.V. Semikhatova in the winter of 1954 - 1955. Their status of new data is asserted by our presentation of new genera of Choristites [12, 13].

In considering the problem of the Lower and Middle Carboniferous boundary, O.L. Eynor states [15, p. 79] that "an obvious majority" of participants in the Kiyev Conference of the Namurian, 1954, were inclined to draw it on the base of Namurian B. There is nothing to that effect in the resolution of the Conference [4] for the simple reason that the resolution reflected the two points of view, each having many advocates.

On the subject of the Lower and Middle Carboniferous boundary, O.L. Eynor notes [15, p. 79] "the inconvenience of drawing this boundary" within his Yakh'insk horizon. Now it has been demonstrated above that the lower part of this "horizon" belongs to the top of Lower Carboniferous, while its upper part belongs to the base of Middle Carboniferous, which makes it necessary to draw the Lower Carboniferous Middle Carboniferous boundary within this horizon.

In arguing with A.P. Rotay, O.L. Eynor believes that the break between the Namurian A and Namurian B is larger than that preceding the Namurian A. It should be emphasized that some geologists have the wrong tendency of stressing tectonic rather than paleontological arguments in favor of stratigraphic breaks, specifically of drawing stratigraphic boundaries always on breaks in sedimentation and on the base of the subsequent transgressions. For instance, there is the tendency of drawing the boundary between the Lower and Middle Carboniferous on the base of the upper Namurian transgression long since known and established in Western Europe.

A stronger expression of a stratigraphic break or a transgression in a region is not a decisive factor in drawing stratigraphic boundaries, specifically those between stages, because such a relationship does not hold true in other regions. Moreover, breaks as well as transgressions are not always contemporaneous and may be altogether missing. We do not embrace the "Stille canon" of simultaneity of tectonic phases and transgressions throughout the entire globe.

The following remark of O.L. Eynor with regard to the Namurian B [15, p. 85] is unfortunate: "A mixed fauna of a horizon intermediate in its stratigraphic position constitutes, as a rule, a sufficient reason for its association with the overlying horizon." The fact is that fauna of the Namurian B is less rejuvenated as compared with Namurian A than that of Namurian C as compared with Namurian B.

Our objections [12] to the O.L. Eynor position with regard to the Namurian stand valid. Above all, we object to his assertion that there is "a lack of certainty in the correlation of West European Namurian with East European sections" [15, p. 86].

In criticizing our objections, in 1958, O.L. Eynor juxtaposes the views of F.N. Chernyshev, A.A. Chernov, and L.S. Librovich, i.e., those dating back to the 19th century and the beginning of the 20th as against those of the present day. This "method" of proof is invalid. O.L. Eynor himself, along with all the Kiev geologists, is in full agreement as to the correlation of Uralian and Donbas sections with the West European. Whether or not they recognize the Namurian as a stage is an altogether different proposition.

In our 1945, 1956, and 1957 works [10, 12, 13] we defended the correlation of the Namurian (Namurian A and B) with the Bashkirian stage, in stratigraphic classifications, on the basis of our proof that Namurian C belonged to the base of the Middle Carboniferous; accordingly, only Namurian A of Western Europe remains in the Lower Carboniferous. Thence he proceeds to the erroneous conclusions that there is no such thing as the Namurian stage, at all. For this reason, he should refrain from referring to the "obvious" justice of his position [15, p. 76].

We have also mentioned [12] the error of O.L. Eynor's opinion that there is no definite stage in the faunal evolution corresponding to the Namurian. In doing that, he stresses the importance of the extinction of species, which is wrong: the now accepted method of drawing stratigraphic boundaries is on the established rejuvenation of a fauna. V.Ye. Ruzhentsov [6] demonstrates in detail that the Namurian is marked by a major and distinct stage in the evolution of the ammonites fauna (Goniotites and Agoniotites). It is to be noted that the boundary in the faunal development of the Namurian A. and B contact (the so-called "flora leap" of V. Hotan) by our paleophytologists [3] who draw the floral boundary between the Lower and Middle Carboniferous at the base of limestone Eg, i.e., on the top of Namurian B or the base of Namurian C of the Heerlen congresses. The change of floras in the Donbas takes place at about this level rather than at the base of formation E = C_1^5 or somewhat below it.

Likewise erroneous is O.L. Eynor's opinion that "Namurian coral fauna is but an impoverished Viséan one; that brachiopods do not undergo much of a rejuvenation in the lower Namurian, with Choristites already present in Namurian B"[15]. Choristites in the Donets basin, if those species are meant whose generic name is identified as Choristites (without the question mark) — are known beginning with the base of limestone E_8. On the other hand, Choristes-like spirifers, such as Spirifer (Choristites?) moeleri Jan., are known in the Donbas not from bed E_1 but from much higher up in the section, bed D_1. Nevertheless, most Kiev geologists draw the Lower Carboniferous - Middle (Bashkirian stage) Carboniferous boundary on the base of limestone E_1 (with the minority drawing it on the base of E_8). On the west slope of the Urals, Choristites are known from deposits correlative with the upper part of formation E in the Donbas; this associates the appearance of Choristites in the Urals with the base of Namurian C of the Heerlen congresses.

Equally unsubstantiated is O.L. Eynor's statement that lower Namurian corals are but impoverished Viséan. As a matter of fact, lower Namurian corals of Scotland, the Moscow region [11], and of the Donbas itself (according to N.P. Vasilyuk) are quite different from the Visean; O.L. Eynor is forced to admit that much himself [15, p. 87].

Finally, O.L. Eynor's assertion that Namurian foraminiferal fauna, too, is but the impoverished Viséan is wrong: Namurian (A + B) foraminiferal assemblage is quite different from the Viséan, because of a number of typical species.

Thus all objections to removing the Namurian stage from the stratigraphic scale remain valid; their criticism by O.L. Eynor does not appear to be well substantiated.

Despite these shortcomings in the analysis of material presented, O.L. Eynor's book, setting forth as it does the results of detailed biostratigraphic study of the Lower and Middle Carboniferous on the west slope of the Urals, is of obvious interest for geologists-stratigraphers who work on coal deposits. O.L. Eynor's data are new and comprehensive, based on a detailed study of several fundamental faunal groups.

REFERENCES

1. Librovich, L.S., Goniatitovyye fauny karbona SSSR i ikh znacheniye dlya stratigrafii etikh otlozheniy. [GONIOTITE FAUNAS OF THE CARBONIFEROUS IN THE USSR AND THEIR VALUE IN THE STRATIGRAPHY OF THESE DEPOSITS]: Byull. MOIP, otd. geol., t. 22, v. 5, 1947.

2. Nikitin, S.N., Kamennougol'nyye otlozheniya Podmoskovnogo kraya i artezianskiye vody pod Moskvoy. [CARBONIFEROUS DEPOSITS OF THE MOSCOW REGION AND ARTESIAN WATERS OF THE MOSCOW AREA]: Tr. Geolkoma, t. v, no. 5, 1890.

3. Novik, K.O., Fitostratigrafichne obgruntuvannya rozchlenyvannya kamyanovugil'nikh vidkladiv Yevropeys'koi chastini SRSR. [PHYTOSTRATIGRAPHIC SUBSTANTIATION OF THE DIFFERENTIATION OF CARBONIFEROUS DEPOSITS IN THE EUROPEAN USSR]: Geologichniy zhurnal, Akad. Nauk UkrSSR, t. xviii, vyp. 3, Kiev, 1958.

4. Rezolyutsiya Soveshcheniya po voprosu ob ob"yeme namyurskogo yarusa i yego polozhenii v kamennougol'noy sisteme (7 - 10 iyunya 1954). [RESOLUTION OF THE CONFERENCE ON THE NAMURIAN INTERVAL AND ITS POSITION IN THE CARBONIFEROUS SYSTEM (JUNE 7-10, 1954)]: Izd., Akad. Nauk USSR, Kiev, 1954.

5. Resheniya Vsesoyuznogo soveshcheniya po vyrabotke unifitsirovannoy skhemy stratigrafii kamennougol'nykh otlozheniy Russkoy platformy i zapadnogo sklona Urala (Leningrad, 1951). [RESOLUTIONS OF THE ALL-UNION CONFERENCE ON A UNIFIED STRATIGRAPHIC SCHEME OF CARBONIFEROUS DEPOSITS IN THE RUSSIAN PLATFORM AND THE WEST URALIAN SLOPE]: Gostoptekhizdat, 1951.

6. Ruzhentsev, V.Ye., Namyurskiy yarus v mirovoy stratigraficheskoy shkale. [THE NAMURIAN STAGE IN THE UNIVERSAL STRATIGRAPHIC SCALE]: Byull. MOIP, otd. geol., t. 33, vyp. 5, 1958.

7. Semikhatova, S.V., Brakhiopody bashkirskikh sloyev SSSR i rod Choristites Fisher. [BRACHIOPODS FROM BASHKIRIAN BEDS OF THE USSR. 1. GENUS Choristites FISHER]: Tr. Paleontol. in-ta, t. xii, vyp. 4, Izd., Akad. Nauk SSSR, 1941.

8. Teodorovich, G.I., K geologii srednego i verkhnego karbona zapadnogo sklona Yuzhnogo Urala. [CONTRIBUTION TO THE GEOLOGY OF MIDDLE AND LOWER CARBONIFEROUS ON THE WEST SLOPE OF THE SOUTH URALS]: Byull. MOIP, otd. geol., t. xiii, vyp. 1, 1935.

9. Teodorovich, G.I., Nekotoryye voprosy stratigrafii kamennougol'nykh otlozheniy zapadnogo sklona Yuzhnogo Urala. [SOME PROBLEMS IN THE STRATIGRAPHY OF CARBONIFEROUS DEPOSITS ON THE WEST SLOPE OF THE SOUTH URALS]: Probl. sov. geol., no. 7, 1936.

10. Teodorovich, G.I., Bashkirskiy yarus

srednego karbona. [MIDDLE CARBONIFEROUS BASHKIRIAN STAGE]: Izv., Akad. Nauk SSSR, ser. geol., no. 5, 1945.

11. Teodorovich, G.I., O bashkirskom i namyurskom yarusakh Yevropeyskoy chasti SSSR. [THE BASHKIRIAN AND NAMURIAN STAGES IN THE EUROPEAN USSR]: Tr. In-ta nefti, Akad. Nauk SSSR, t. III, 1954.

12. Teodorovich, G.I., Podrazdeleniya opornykh razrezov bashkirskogo yarusa Gornoy Bashkirii na faunisticheskiye gorizonty. [DIFFERENTIATION OF CONTROL SECTIONS OF THE BASHKIRIAN STAGE IN MOUNTAINOUS BASHKIRIYA, INTO FAUNAL HORIZONS]: Byull. MOIP, otd. geol., t. xxxii, no. 3, 1957.

13. Teodorovich, G.I., L.P. Grozdilova and N.S. Lebedeva, Podrazdeleniye bashkirskogo yarusa Gornoy Bashkirii po faune foraminifer. [DIFFERENTIATION OF THE BASHKIRIAN STAGE OF MOUNTAINOUS BASHKIRIYA,BY FORAMINIFERAI FAUNA]: Dokl. Akad. Nauk SSSR, t. 111, no. 2, 1956.

14. Eynor, O.L., Bashkirskiy yarus v Gornoy Bashkirii. [BASHKIRIAN STAGE IN MOUNTAINOUS BASHKIRIYA]: Dokl. Akad. Nauk SSSR, nov. ser., t. 104, no. 1, 1955.

15. Eynor, O.L., Issledoyaniya po stratigrafii karbona vostochnoy okrainy Uralo-Volzhskoy neftonosnoy oblasti (Gornaya Bashkiriya). [STRATIGRAPHIC STUDIES OF THE CARBONIFEROUS FROM THE EAST MARGIN OF THE URAL-VOLGA PETROLEUM PROVINCE (MOUNTAINOUS BASHKIRIYA]: Lengostoptekhizdat, L., 1958.

16. Congrés pour l'avancement des ètudes de stratigraphie carbonifère. Heerlen, 7 - 11 juin, 1927, Liège, 1928.

17. Deuxième Congrès pour l'avancement des études de stratigraphie carbonifère. Heerlen, septembre 1935, t. I et II, Maestricht, 1937, t. III, 1938.

18. Purves, J.C., Explication de la famille de Natoye (Le terrain houiller, étage namurien): Musée Royal d'Histoire Naturelle de Belgique, Service de al carte géologique du royaume, Bruxelles, 1883.

STUDY OF ERUPTIONS AND EARTHQUAKES ORIGINATING FROM VOLCANOES (PART 3 OF 3)[1]

RELATION BETWEEN DEPTH OF VOLCANIC EARTHQUAKES AND SUBSEQUENT VOLCANIC PHENOMENA

by

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• *translated by Kinkiti Musya* •

ABSTRACT

Investigations using various seismographs to determine positions of volcanogenic earthquakes have been underway at Asama for 25 years. The types of earthquake observed here through this period are mainly very shallow (B-type). Measurements taken with instruments spotted over the mountain made it possible to locate the epicenters with accuracy. Very few were deeper than 1 km. While the B-type earthquake prevailed throughout both quiescent and pre-active stages, the concurrent deeper A-type quakes showed a sharp decrease in the month just prior to the October 3 explosive eruption, while the tremors of shallow origin increased in intensity and frequency. After the December series of the 1958 eruptive period, earthquakes were of much deeper origin prior to and between the major explosions. Comparison is drawn to the 1943-1945 activity of Usu, where A-type earthquakes predominated and B-type earthquakes appeared only just prior to the eruptions. The writers suggest that depth of hypocenter as well as frequency of such earthquakes can be used to make eruption predictions.-A. Eustus.

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INTRODUCTION

In the first report, earthquakes originating from volcanoes were classified into 4 types based on positions of hypocenters and relation between earthquakes and volcanic eruptions. In the present paper, the relation between earthquakes originating from volcanoes and eruptions of the volcanoes will be discussed from the viewpoint of the focal depth of these earthquakes.

Volcanic eruptions occur when subterranean magma is erupted to the earth's surface. It follows that the eruption of magma cannot occur without overcoming internal friction, destroying part of a mountain body, and resisting the force of gravity through successive stages from the genesis and upward movement of magma to its outpouring on the earth's surface. Consequently, due to a force working from below, strong stress is bound to be produced in the earth's crust between a magma reservoir and the earth's surface. Hence, it is reasonable to expect that the eruption of magma is accompanied by earthquakes and by local changes in topography. Thus, hypocenters and the mode of occurrence of earthquakes originating from a volcanic area may be considered as closely related to the position of magma, its process of movement, and the stress applied to the mountain body. Important information related to the production of magma and to its eruption to the earth's surface should be obtained by detailed study of earthquakes originating from and near volcanoes. Kuno (1959) made an interesting study of the geographical distribution of earthquake hypocenters, the distribution of volcanoes, the depth of magma reservoirs, and the character of rocks in Japan and in adjacent regions. Although the maximum depth of earthquake foci originating from and near volcanoes does not indicate the depth of magma reservoir, it is noted that the hypocenters of earthquakes originating from basaltic volcanoes (Kilauea, Mauna Loa (Jones, 1935), Ō-shima, etc.) are generally deeper than those from andesitic volcanoes. Whether or not these observations indicate the depth where magma is produced or where magma reservoirs lie in the earth's crust is a problem for consideration. Accordingly, study of earthquakes originating from volcanoes has an important bearing on fundamental aspects of volcanic phenomena. This problem will be solved step-by-step by studying several volcanoes in detail from various standpoints. Results of the study of earthquake hypocenters during the activity of Asama volcano and during the 1944 activity of Usu-san will be presented.

DEPTH OF HYPOCENTERS VOLCANIC EARTHQUAKES

Generally speaking, in the case of nearly [nearby?] earthquakes, the positions of the hypocenters are determined by observing the duration of preliminary tremors, the arrival time of the initial motion, etc. However, most earthquakes originating from volcanoes are of very shallow origin. Therefore, besides the above method, for example, it is often more convenient to determine the hypocenters by the attenuation of maximum amplitude in accordance with the epicentral distance. Particularly, most earthquakes originating in swarms from Asama volcano and earthquakes which accompanied the activity of Minami-dake (Minakami, Mogi et al., 1959) in Sakura-jima, as described in the first

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[1]Translated from the Japanese: in Kazan [Bulletin of the Volcanological Society of Japan], vol. 4, no. 3, pp. 133-151. Parts 1 and 2 appeared in International Geology Review, v. 3, nos. 8 and 9, pp. 712 and 803.

[2]Earthquake Research Institute, University of Tokyo.

and second reports (Minakami 1959; Minikami, Hirago, et al., 1959), all have very shallow hypocenters. In these cases the determination of hypocenters by the distribution of the amplitudes is most convenient. It was found from seismograms obtained at several stations that rather deep A-type earthquakes having hypocenters 1 to 10 km deep, such as the remarkable earthquakes which occurred during the growth of Shōwa-Shinzan in Usu volcano, are distinctly different in apparent attenuation of amplitudes from B-type earthquakes which originated from the very shallow part of the upheaved area where Shōwa-Shinzan was built up. Thus, the depth of hypocenters distinctly differs in earthquakes of the two types, and constitutes an important characteristic of hypocenter distribution. Moreover, because earthquake motion of B-type earthquakes recorded at each station is almost constant in amplitude ratio and because earthquake motion observed at each station is similar, it is confirmed that B-type earthquakes are not only shallow, but also occur in swarms from a narrow area. The earthquakes which occurred in connection with the 1943-1945 activity of Usu-san afforded an outstanding example that the nature of earthquake motion is related to location of hypocenters.

Before considering the distribution of earthquake hypocenters originating from Asama volcano, the writers refer to Omori's study (1914) of earthquakes originating from Asama volcano. Omori established a volcanological observatory in 1910 at Yunotaira, 2.0 km southwest of the volcano's crater. With seismograph and other instruments set up at the observatory, he made observations of earthquakes which accompanied the remarkable 1910-1913 activity. His study of the relation between the earthquakes and the volcanic eruptions is classic for that time. Omori classified earthquakes which originated from Asama volcano into earthquakes accompanied by eruption (explosion earthquakes) and earthquakes not accompanied by eruptions. He called the former volcanic earthquakes of B-type and the latter volcanic earthquakes of A-type. As mentioned in the previous paper, A-type and B-type earthquakes of Omori are different from A-type and B-type as defined by the writers. B-type earthquakes of Omori correspond to earthquakes called explosion (eruption) earthquakes by the writers. The results obtained by Omori from observation at one station are not greatly different from the results obtained by the writers with regard to earthquake motion and the location of hypocenters a short distance below the crater bottom.

B-type earthquakes of the writers are those which take place in swarms in a shallow, restricted area beneath the crater. The positions of these hypocenters and their earthquake motion resemble those from explosion earthquakes and are difficult to distinguish. However, an important discovery made from observations in recent years indicates that the motions of explosion earthquakes are generally larger than those of B-type earthquakes (fig. 1).

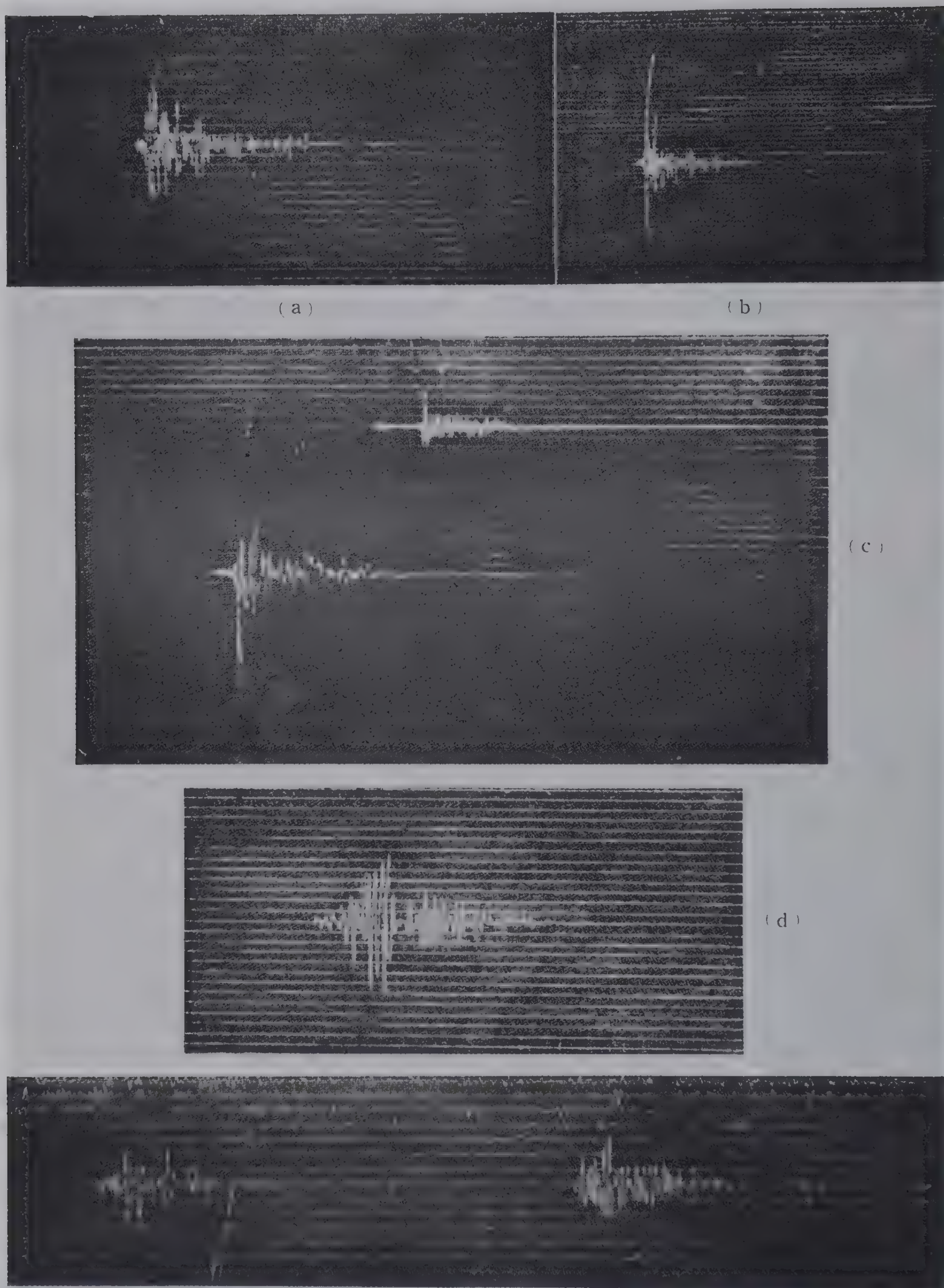
On the other hand, the hypocenters of A-type earthquakes, those which accompanied the 1943-1945 activity of Usu-san for example, are distributed in a rather deep part (generally deeper than 1 km) and in a wider area than those of B-type earthquakes. In seismograms of A-type earthquakes, P and S phases are easily recognized and earthquake motion is not distinguishable from those earthquakes originating from non-volcanic areas. On the contrary, most B-type earthquakes are characterized by an indistinct S-phase and the predominance of the surface waves.

Consequently the writers' A-type and B-type earthquakes are included in Omori's A-type earthquakes. It is possible that Omori's A-type earthquakes of small amplitude may possibly be equivalent to the writers' shallow B-type earthquakes which originate from the vicinity of the crater.

OBSERVATIONS OF VOLCANIC EARTHQUAKES FROM ASAMA VOLCANO

Seismometrical observation carried out by Omori was classic for that time. However, his observation was conducted with a seismograph of low magnification at the one Yunotaira station. Hence, it was inevitable that he could not determine the distribution of hypocenters of A-type and B-type earthquakes.

According to seismometric reports of the Oiwake Weather Station (Minikami et al, 1951) 8 km distant from the crater, earthquakes which originated from Asama volcano have been recorded as "tremors" from time to time, but useful data on their hypocenters cannot be found. In order to locate hypocenters, simultaneous observations have been made since 1934 with seismographs of magnification 350 with the Asama Volcano Observatory (Minikami et al., 1959) as the central station 8 km distant from the crater. A Wood-Anderson and other seismographs of high magnification, set up at Yunotaira, Komoro, Oni-oshidashi, and Kutsukake, sometimes were used. However, this attempt was not successful for a long time mainly due to the rare occurrence of A-type earthquakes having deep hypocenters and amplitudes more than 5μ. Only several dozen earthquakes of this type were recorded during the past 25 years, and during this time, there was almost no noticeable earthquake. Actually, few earthquakes originated from depths greater than 1-2 km below Asama volcano during the past 25 years, and their magnitudes have been small. On the other hand, shallow earthquakes occurred very frequently, but their phases were indistinct in seismograms recorded at the foot of the volcano. Therefore, these earthquakes were called volcanic tremors



(e)

FIGURE 1. Seismograms of various types of earthquakes, which were recorded by the same type of the horizontal seismograph.

(a) - The A-type earthquake originating from Asama.
(b) - The A-type earthquake originating from Usu.
(c) - An after-shock of the 1948 Hukui earthquake.
(d) - The B-type earthquake originating from Asama.
(e) - The B-type earthquake originating from Usu.

and it could be inferred that their hypocenters were located near the crater. From the seismometric point of view, it was impossible to make a complete interpretation on the basis of these earthquakes. Since 1950, rather systematic observation has been conducted. For these observations mechanical-optical seismographs of magnification 4,000-7,000 were used at 5 stations around the crater in 1952 and at 6 stations in 1953 for about 40 days respectively. Neither station was provided with alternating power. Therefore, until 1956 the writers were obliged to rotate the seismograph recording drum with a mechanical driver and to use a storage battery as a light source. In order to record the exact time the J. J. Y. signals were referred to at each station and time was marked on the recording paper at every minute and second. However, because the turning speed was not constant, it required much time to interpret these seismograms.

Besides a mechanical-optical seismograph, telerecording by means of an electromagnetic seismograph directly connected with a galvanometer, was begun in 1954.

In 1955, transducers were set up at seven stations and records were transmitted to Station No. II (Sanno-torii) by telerecording. However, because alternating power was not yet available and, it proved too laborious to carry an accumulator [storage battery?] to the recorder station.

In 1956, it became possible to transmit records to the Asama Volcano Observatory 4. 2 km east of the crater.

On December 24, 1956, 24 years after the observatory was established, alternating power was provided for the first time. Consequently, observation became much easier because an amplifier and other instruments became usable for continuous observation of earthquakes and explosion sounds. Moreover, because it became possible to record earthquake motion transmitted from each station on a drum or drums with the same rotating velocity, it is now easy to compare seismograms recorded at various stations and the labor of calculation has been greatly reduced. This obviously contributed to the improvement of observation accuracy.

The stations where seismometric observations have been made since 1950 are shown in Figure 2.

As described above, the writers had been obliged to make observations with a recording apparatus driven by a spring or a weight and with a dry cell and an accumulator[?] as a light source until 1957 when electric power was provided. A telerecording apparatus adopted by the writers is usable in the event that the electric power supply is interrupted at either the transducer or recording station. Hence this apparatus can be used even in a remote place.

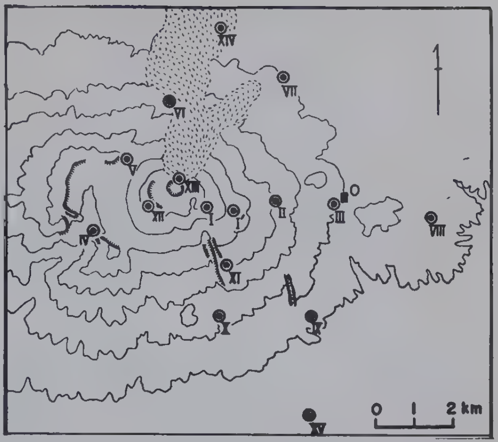


FIGURE 2. The location of seismographs and transducers on and around Volcano Asama (I-XV).

O - Asama volcano observatory.

The writers' long years of laborious observation would have been impossible without the cooperation of many persons. The writer particularly thank Messrs. Kinoshita, Hayatsu, Kato, Kojima, Fujita, Kobayashi, and Nawa, who at that time were students of the Geophysical Institute, Tokyo University.

DISTRIBUTION OF HYPOCENTERS OF B-TYPE EARTHQUAKES ORIGINATING FROM ASAMA VOLCANO

The writers observed microearthquakes originating from Asama volcano by the above-mentioned method with seismographs set up as shown in Figure 2. Initially, the positions of microearthquake hypocenters will be discussed.

Figure 3. shows the geographical distribution of microearthquakes selected from seismograms which were recorded with a mechanical-optical seismograph (pendulum period, 1 sec.; J. J. Y. time, marked by minute and second; July to September, 1952, 1953, and 1954). Microearthquakes shown in Figure 3 are those whose P-S duration is distinct and whose hypocenters were determined on the basis of arrival time of the P-wave. In 1953, observation was carried out at 6 stations. Seismographs set up at each of these stations were of the same type and of almost the same magnification (4,000 times). The daily frequency of volcanic earthquakes recorded at respective stations is shown in Figure 4. As is evident in Figure 4, the changes of daily frequency are almost parallel at the 6 stations. For about 10 days beginning on August 2 swarms of earthquakes was distinctly recorded at all 6 stations. More and larger earthquakes were recorded at stations close to the crater.

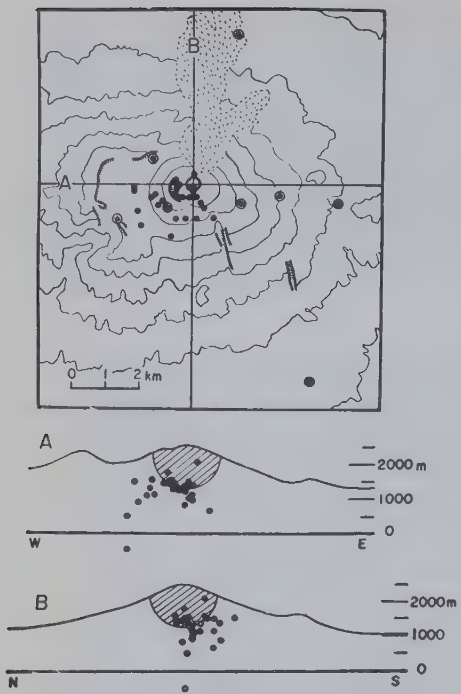


FIGURE 3. Geographical distribution of earthquakes originating from Volcano Asama. Hatched area: indicating the hypocentral domain of the B-type earthquakes.

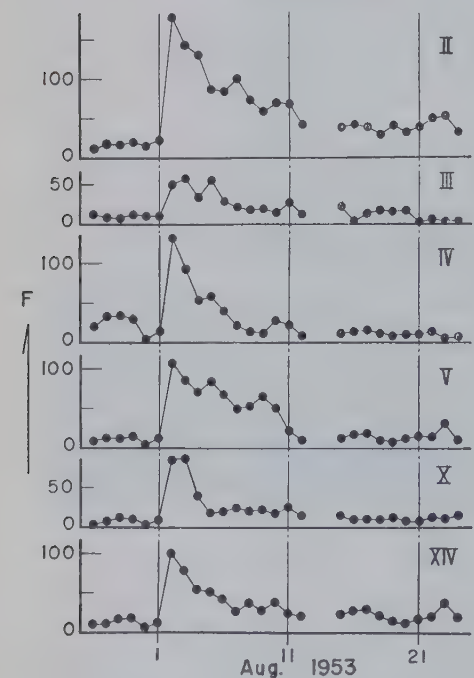


FIGURE 4. Daily frequency of the Asama earthquakes observed at seven stations (fig. 2) during the period from July 27 to August 24, 1953.

It is doubtless that these seismographs recorded the same earthquakes which originated from almost the same hypocenters and that these earthquakes occurred in swarms in the vicinity of the crater. In addition, the above results indicate that the hypocenters were very shallow as compared with earthquakes of tectonic origin. The distribution of hypocenters shown in Figure 3 includes not only relatively large and deep B-type earthquakes but also A-type earthquakes. It may be deduced that the hypocenters of most B-type earthquakes which are not shown in Figure 3 lie in a domain about 1 km in radius with the surface of the crater as the center. Investigation carried out by considering amplitude distribution of earthquake motion and the travel time of initial motion as will be described later, showed that most microearthquakes recorded in Asama volcano are again found to originate from the crater bottom and its surroundings. In addition, according to data obtained from the remarkable activity which began in October 1958, the pre-eruption earthquakes were classified as B-type earthquakes which originated mainly from and near the crater bottom. However, further study revealed that, during the activity of October to December 1958, earthquakes which occurred as the forerunners of the eruption originated from a rather wide area with the crater as the center. Their earthquake motions resembled those of the volcano in quiescent period.

The writers reported previously on the explosive eruption at the summit crater of Minami-dake in Sakura-jima in 1955 and on earthquakes which accompanied the eruption. Most earthquakes which took place during the activity were very shallow (B-type earthquakes) having the crater of Minami-dake as their center. As previously described, the explosive eruptions of Minami-dake resemble those of Asama volcano and earthquakes originating from Minami-dake also resemble B-type earthquakes of Asama volcano in character and mode of occurrence.

To cite another example, during the famous 1943-1945 eruption of Usu-san when Shōwa-Shinzan was built up, besides A-type earthquakes, very shallow earthquakes, or, B-type earthquakes frequently occurred in areas where topographical changes such as upheaval of the ground and the formation of Shōwa-Shinzan took place.

Judging from the above examples, it may probably be concluded that the frequent occurrence of B-type earthquakes prior to eruptions is a general characteristic of volcanoes which display explosive eruptions, namely, volcanoes ejecting andesitic or dacitic lava.

DISTRIBUTION OF HYPOCENTERS OF A-TYPE EARTHQUAKES IN ASAMA VOLCANO AND IN OTHER VOLCANOES

It has been reported in detail in the publications of the Hawaiian Volcano Observatory and

elsewhere that earthquakes originate frequently from depths of several km to several tens of km beneath Kilauea and Mauna Loa on Hawaii Island. Occasionally, considerable damage is caused in the city of Hilo and in other towns and villages. Therefore, it is evident that A-type earthquakes occur frequently in that island. However, according to Furumoto, (Furumoto, 1951) the relation between the occurrence of earthquakes and the eruptions of the two volcanoes is not always clear.

In Ō-shima (Mihara-yama), noticeable earthquakes frequently occur in swarms. The distribution of earthquake hypocenters during June 1938, was studied by Takahasi et al. (and Nagata, 1939), who determined that the hypocenters extended from the earth's surface to a depth of about 8 km. Judging from the value of Omori's coefficient determined at that and at other times, several earthquakes thought to have originated near the earth's surface might actually have occurred from a greater depth.

Seismometric observation carried out during the 1940 eruption of Miyake-shima and for about one year after (Minikami and Hiraga, no date; Hagiwara, 1941) revealed that A-type earthquakes (including noticeable earthquakes) originated from the depths of several km under the volcano, even though seismographs of low magnification were used.

Ō-shima, Miyake-shima, and the above-mentioned two volcanoes in the Hawaii Islands erupt basaltic lava. A-type earthquakes (including noticeable earthquakes) frequently take place at depths ranging from 1 or 2 km up to 40 km. On the other hand, it is noteworthy that neither very shallow earthquakes originating from the vicinity of the crater nor B-type earthquakes have been observed. This problem will be discussed later.

In Asama volcano, at least during the last 25 years when the writers made various seismometric observations, A-type earthquakes were negligible in frequency as compared with B-type earthquakes, i. e., 0. 1 percent or less of the total number of volcanic earthquakes which were recorded. Noticeable earthquakes of A-type were extremely rare. This is a noteworthy characteristic of the seismic activity in Asama volcano, and has not been found in other volcanoes. The first and second papers were concerned only with the frequency of Asama's B-type earthquakes. However, it should be noted that A-type earthquakes do occur on occasion. For example, 30 minutes before the great explosive eruption of November 10, 1958, an A-type earthquake which was exceptional for Asama volcano, although unnoticed by local inhabitants, was recorded with seismographs of low magnification (x 350, period: 1 sec.) at three stations around the volcano. The duration of preliminary tremors and the maximum amplitude of this earthquake were as follows:

Station	Duration of preliminary tremors	Maximum amplitude
Karuizawa (Asama Volc. Obs.)	1. 2-1. 6 sec.	14 μ
Komoro (Kormor Br. Off., E. R. I.)	2. 3-2. 6	15 μ
Oiwake (Oiwake Weath. St., J. M. A.)	1. 1-1. 2	28 μ

The hypocenter of this earthquake was determined to be a point near Sekison-zan, about 3. 5 km S by E of the crater and 3 to 4 km in depth. This determination was made on the basis of the relation between the depth of hypocenter and distance coefficiency (k) assumed from results of investigations of A-type earthquakes in Usu-san.

Concerning the position of A-type hypocenter in Asama volcano determined by seismometric observations made to date, it has been found that, though there is room for doubt due to the paucity of observed earthquakes, A-type earthquakes originate relatively frequently from an area from 1 to 5 km in radius on the west side of the volcano and very rarely on the east side.

In Sakura-jima, a volcano ejecting andesitic lava and whose eruptions resemble those of Asama volcano, noticeable A-type earthquakes originate under and near the volcano more frequently than at Asama volcano.

In the case of recorded eruptions of Usu-san as described above, A-type earthquakes are observed without exception, and are especially common prior to eruptions.

However, in Asama volcano the occurrence of A-type earthquakes is rare. To what may this be attributed? This is an interesting problem, but a definite solution has not been found to date. At present the only answer to this problem is that the above difference is not caused by the nature of erupted lava but rather by certain conditions peculiar to Asama volcano, including the position of the crater and the magma reservoir, and the structure connecting the former with the latter.

On the other hand, the preponderance of earthquakes in swarms in the shallow part of the crater may be explained by the assumption that most thermal energy is transformed into vibration near the earth's surface and just a small portion of the energy is transformed into vibration at deeper depths.

It has been confirmed at Shōwa-Shinzan and from various observations at Asama volcano in recent years that B-type earthquakes occur when

the crater area and the epicentral area coincide with the center of the dome-like upheaval.

RELATION BETWEEN THE AMPLITUDES AND THE EPICENTRAL DISTANCE OF B-TYPE EARTHQUAKES FROM ASAMA VOLCANO

It has been determined from the arrival time of the P-wave, the duration of preliminary tremors, and the frequency distribution of earthquakes that B-type earthquakes originate in swarms from a shallow depth beneath the summit crater. It is quite reasonable that the amplitudes of earthquake motion recorded with seismographs of the same type and magnification at various distances from the crater are remarkably attenuated with increasing distance from the crater or epicenter. It is also reasonable that the more the amplitudes are attenuated per unit of epicentral distance, the shallower the hypocenter is.

In order to investigate this problem in detail, special care was taken to keep the magnification of seismographs constant. Observation was conducted by three methods, and the same results were obtained by each method. An example of observation made by connecting transducers with galvanometers is shown below. The maximum amplitudes of earthquake motion recorded at Stations No. I, No. II, and No. III are compared. These stations are arranged in a straight line along the eastern observation line of the volcano. Figure 5 and Figure 6 show the distribution of the maximum amplitude ratio of station No. I to station No. II and that of Station No. II to Station No. III respectively. These stations were established for the observation of B-type earthquakes while the volcano was calm. As seen in the two figures, the amplitude ratios are irregularly arranged in each respective earthquake, but, in general, the dots lie along a straight line showing the ratio of approximately 1:0.45 for No. I/No. II and of approximately 1:0.29 for No. II/No. III. Of the three stations, No. I and No. II are underground, constructed in layers of pumice, lapilli, and volcanic ash of the same age. The nature of ground for earthquake motion at the two localities is almost the same. Station No. III is constructed in a cave in massive dacitic lava. The ground is quite different from that of Stations No. I and No. II. Comparison is made of the ground coefficient of vibration having a period of 0.3-0.8 sec. at each respective station determined on the basis of seismograms of earthquakes originating from Kashima-nada and from the southern part of the Kwantō district. As the amplitude at Station No. III becomes equal to that of other stations by doubling or trebling the above vibration period, it is supposed that the ground coefficient is different by much as 2 to 3 times. Hence, when propagation and attenuation of seismic waves are discussed, it is necessary to consider the effect of the ground coefficient.

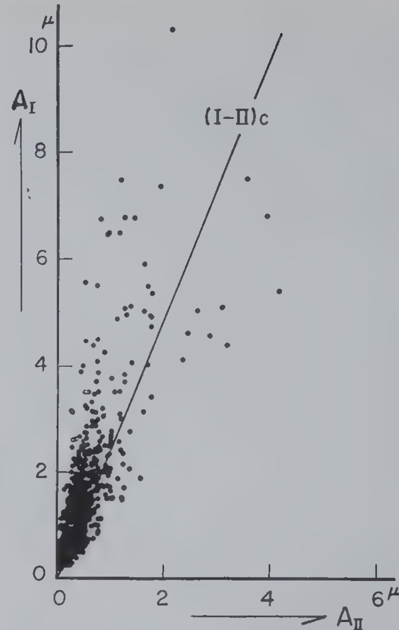


FIGURE 5. Comparison of the maximum amplitudes (A_I) of the B-type earthquakes at the Station No. I with those (A_{II}) at the Station No. II, in the quiescent state of Asama from Jan. to May, 1957.

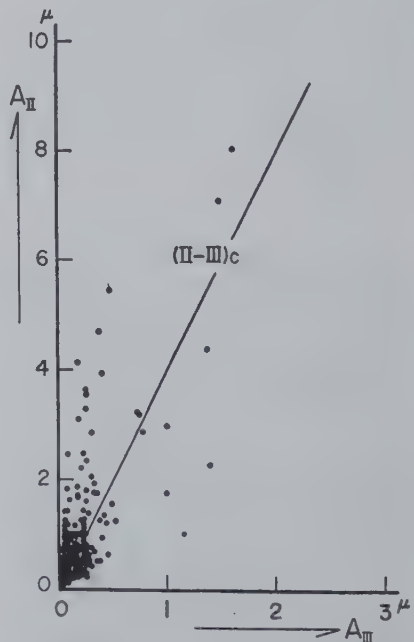


FIGURE 6. Comparison of the maximum amplitudes (A_{II}) of the B-type earthquakes at the Station No. II with those (A_{III}) at the Station No. III in the quiescent state of Asama from Jan. to May 1957.

Even when the amplitude ratio at the three stations is compared taking the ground efficient into account, there are no exceptions in respective earthquakes, regardless of distance from station to epicenter. In other words, the amplitude of earthquake motions indicate that the hypocenters of B-type earthquakes are concentrated around the crater. In addition, considering the attenuation of earthquake motion as a function of epicentral distance, the hypocenters are doubtless located at a very shallow depth beneath the crater (for instance, not more than 500 meters deep).

B-TYPE EARTHQUAKES DIRECTLY RELATED TO PRE-ERUPTION PHENOMENA AND B-TYPE EARTHQUAKES NOT HAVING A DIRECT RELATION TO ERUPTIONS

In the first and second reports, the relation between B-type earthquakes and the occurrence of eruptions was discussed only on the basis of the frequency of B-type earthquakes as pre-eruption premonitory phenomena of Asama volcano. However, when B-type earthquakes are treated, it is considered necessary that additional elements be investigated in detail (for example, slight differences in the positions of hypocenters, the character and the magnitude of earthquake motion, etc.). That is, whether the character of B-type earthquakes in quiescent periods is different from that of B-type earthquakes in active periods. Particularly important is whether or not there is any characteristic of B-type earthquakes which occurs several days before violent explosive eruptions that might disclose the mechanism of volcanic activity and might permit the prediction of volcanic eruptions.

The maximum amplitude ratio at stations No. I, No. II, and No. III one day before the remarkable explosive eruption of November 10, 1958, is shown in Figure 7 and Figure 8. The mean ratio is 1:0.41 at Stations No. I and No. II and 1:0.7 at Stations No. II and No. III respectively. The mean ratio in the calm period given previously is shown in the same figures to permit ready comparison. As is evident in the figures, the amplitude ratio (particularly at Stations No. II and No. III) becomes larger just before explosive eruptions as compared with that in the quiescent period. That is, the rate that the amplitude of B-type earthquakes attenuates with the epicentral distance is unusually great prior to large eruptions. This indicates that B-type earthquakes in such cases originate from a shallower depth than earthquakes of the same

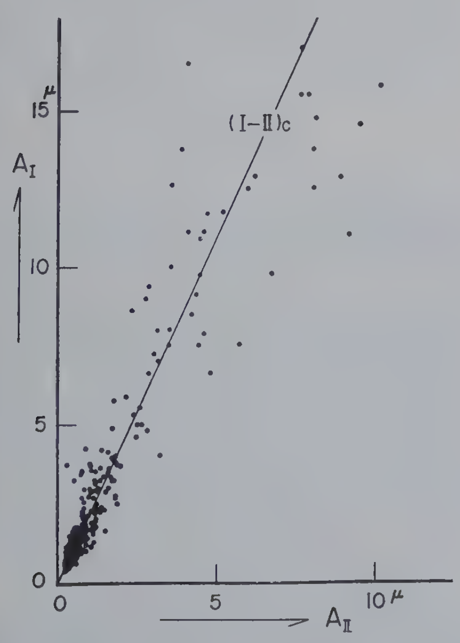


FIGURE 7. Comparison of the maximum amplitudes (A_I) of the B-type earthquakes with those (A_{II}), which were observed at one and two days preceding the violent explosive eruption on November 10, 1958

$(I-II)_c$ - indicating the same relation in the quiescent state of the volcano (fig. 5).

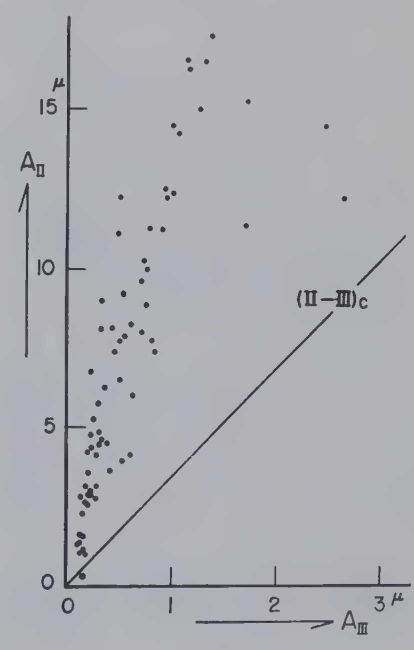


FIGURE 8. Comparison of the maximum amplitudes (A_{II}) of the B-type earthquakes with those (A_{III}), which were observed at one and two days preceding the violent explosive eruption on November 10, 1958.

$(II-III)_c$ - indicating the same relation in the quiescent state of the volcano (fig. 6).

type during calm periods. As described above, B-type earthquakes which originate from a narrow area near the crater in quiescent periods have different hypocentral depths than those that occur just before explosive eruptions. It is noteworthy that the ratio of amplitude of earthquake motion differed considerably at the stations whose epicentral distances at both times were not the same. Therefore, concerning the depths of the hypocenters of shallow earthquakes with practically identical epicenters, comparison of the amplitudes observed at more than two stations with different epicentral distances can reveal, distinctly though relatively, the change of the depth of such shallow earthquakes.

In Figure 7 of the second report (Minikami, Hiraga, et al., 1959)[3] which shows the relation between eruptions and the distribution of daily frequency of B-type earthquakes at Station No. II, a remarkable increase of frequency was perceived from December 25 to 28. This increase of earthquakes seemed to foretell a large eruption which would occur within several days. However, an explosive eruption of the size expected by the writers did not occur. Moreover, after the occurrence of this earthquake swarm, the eruptive activity which had been active up to that time waned and at the same time the frequency of earthquakes abruptly decreased. Therefore, this earthquake swarm is noteworthy, and might have been caused by some phenomena of unknown origin in or below the crater bottom. The data collected at station II and III during this swarm are compared in Figure 9. In this figure, the maximum amplitudes of B-type earthquakes at the two stations in the calm period are shown with a straight line for the purpose of comparison. As is evident in this figure, the ratio of the amplitudes at Stations No. II and No. III in the active period was remarkably small as compared with that in the quiescent period. Hence, the above earthquake swarm was quite different from the earthquake swarms preceding volcanic eruptions. In short, it is concluded that the earthquake swarm of December 26, though the earthquakes were of B-type, originated from a depth below the crater greater than those in the calm and prevolcanic period. Though B-type earthquakes of this type have a relation to volcanic activity, they need not be followed by eruptions.

As described above, B-type earthquakes are classified into those of rather deep origin and those of extremely shallow origin. These two types of B-type earthquakes are related differently to volcanic eruptions.

One last example of the relation between eruptions of Asama volcano and microearthquakes originating from the volcano will be mentioned.

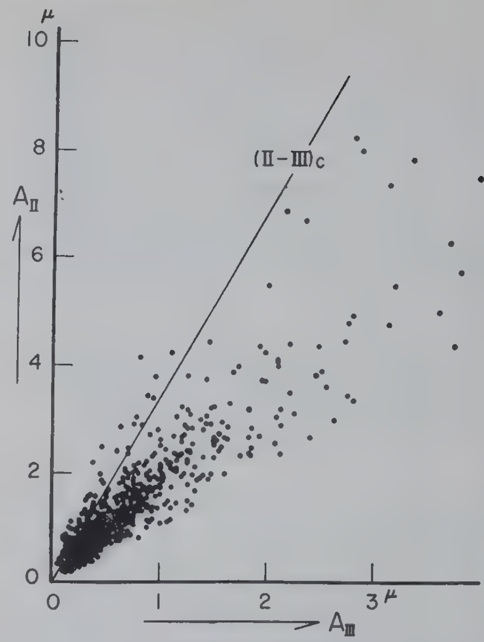


FIGURE 9. Comparison of the maximum amplitudes (A_{II}) of the B-type earthquakes with those (A_{III}), which were observed on Dec. 25 and 26, 1958, soon after the series of strong eruptions including those on Dec. 4, 5, and 14, and were not followed by strong eruption.

(II-III) - indicating the same relation in the quiescent state of the volcano (fig. 6).

The daily frequency of B-type earthquakes observed with transducers (magnification: 4,000 times) at Stations No. I and No. II before and after the rather remarkable explosive eruption of June 11, 1955 is shown in Figure 10. In this case microearthquakes abruptly increased six days prior to the eruption. On the basis of the vulnerability ratio it was expected several days prior to the explosion eruption that grave danger was imminent. To investigate the character of B-type earthquakes which occurred at this time, the frequency of those observed at Station No. I was compared with that at Station No. II. In Figure 11, the daily earthquake frequency at Station No. I is plotted on the ordinate and that at Station No. II on the abscissa. In the calm period, dots representing the daily frequency of both stations are scattered approximately along a straight line. But five days before the eruption, the frequency at Station No. I became much greater than that at Station No. II and the dots deviated far from the straight line. This is very similar to the previous example, and the coming eruption was heralded by increase of daily frequency rather than by increase of amplitudes. These B-type earthquakes which increased abruptly before the eruption recorded only at Station No. I. Most of them were not recorded at Station No. II because

[3] IGR, August 1961 p. 803.

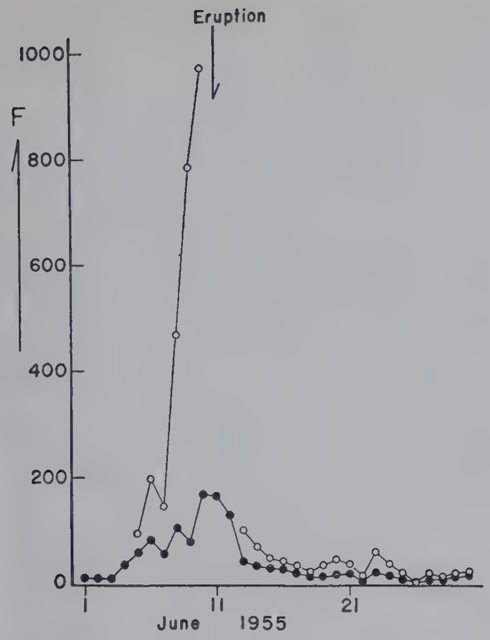


FIGURE 10. Daily frequency of the B-type earthquakes which took place before and after the strong eruption on June 11, 1955.

● - daily frequency observed at the Station No. I.
o - daily frequency observed at the Station No. II.

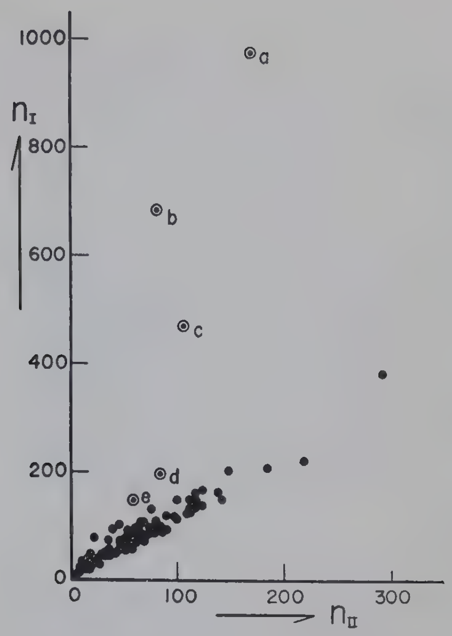


FIGURE 11. Comparison of daily frequencies (n_I, n_{II}) of the B-type earthquakes before and after the strong eruption on June 11, 1955, which were observed at the Stations No. I, and No. II.

a, b, c, d, and e - indicating the daily frequencies from one day to five days preceding the eruption.

these earthquakes were relatively small and their hypocenters were extremely shallow.

On the other hand, when viewed from the nature of earthquake motion, these B-type earthquakes involve those of the shock type, those characterized by predominant surface waves, and those accompanied by vibrations whose later stages are not liable to attenuate. The last-cited vibrations are considered to be due to air vibration in the crater or in the conduit connected to the crater. These phenomena will be reported in another paper.

If B-type earthquakes from Asama volcano are classified according to the depth of their hypocenters and the relation between an explosive eruption and earthquakes is investigated, the existing curve showing the vulnerability ratio can be narrowed and made more effective. In short, it is suspected that the time lag between eruptions and very shallow B-type earthquakes is different from the lag following deep quakes. These problems are expected to be clarified in the near future.

MUTUAL RELATION BETWEEN A-TYPE AND B-TYPE EARTHQUAKES AND ERUPTIONS, WITH ESPECIAL REFERENCE TO THE 1943-1945 ACTIVITY OF USU-SAN

Some problems concerning B-type earthquakes originating from Asama Volcano and related explosive eruptions of the volcano were discussed above. As was already reported in the previous issue of this journal, the writers' observation data of eruption of Sakura-jima should be restudied by supplementing them with the data of quiescent period observation. It is assumed that Sakura-jima and other volcanoes which behave somewhat like Volcano Asama would also resemble it in earthquake depth relations.

In this chapter, the relation between the earthquakes and eruption during the well known eruption of Usu-san, when Shōwa-Shinzan was built up, will be mainly discussed. This activity was accompanied by frequent A-type and B-type earthquakes and the relation of these earthquakes to the eruption and to the upheaval phenomena was observed carefully and meas-

ured precisely.

On December 27, 1943, the district around Usu-san was shaken by a strong but local earthquake; then many felt earthquakes occurred in succession. By the end of January 1944, earthquakes felt in the neighborhood of Usu-san considerably decreased in frequency, but the occurrence of earthquakes did not entirely cease until Shōwa-Shinzan reached its full growth, approximately at the end of 1945. According to the observation made by one of the writers from March 1944 to April 1945, these were A-type earthquakes, whose hypocenters were widely distributed under the south side of Usu-san and at a depth of 1-8 km. On the other hand, from about February 1944 very local and shallow B-type earthquakes accompanied the remarkable upheaval of the ground and the formation of faultlike fissures in the hamlet of Yanagiwara at the eastern foot of Usu-san. Some of these B-type earthquakes were felt within an area 0.3-0.5 km in radius from the epicenters, but the earthquake motion attenuated rapidly with distance. For example, only the larger B-type earthquakes were recorded with a seismograph of magnification 350 at the spa of Toya, about 5 km distant from the epicenters. Afterwards, the area of upheaval migrated about 1 km to the north, and the dome-like upheaval continued. On June 23, 1944, steam eruption began from the central part of the upheaval area, and continued for five months. Then heavy viscous lava rose to the earth's surface, and a lava dome was formed. B-type earthquakes began to occur with the commencement of upheaval in Yanagiwara, and the earthquakes were most remarkable before, during, and after the explosive eruption. Earthquakes which occurred between early development of the lava-dome and its maturity had their hypocenters in the neighborhood of the central part of the upheaval area in which the above-mentioned lava dome was gradually growing. However, it is evident from the results of seismometric observation at the meteorological observatories of Sapporo and Muroran (Kizawa, 1957) and from the observation made by the writers at various stations near the epicenters that these earthquake hypocenters were slightly deeper than those of the B-type earthquakes which had occurred up to that time. This is also reflected by the fact that B-type earthquakes which occurred frequently from June to October 1944 were observed only at stations near their epicenters, while those which accompanied the development of the lava dome were recorded at every above-mentioned station. One of the writers previously reported that the earthquakes which accompanied the development of the lava dome possessed a peculiar characteristic. He distinguished these earthquakes from B-type earthquakes and called them C-type earthquakes because of their rather deep hypocenters and because of the above-described reason. However, these earthquakes are now regarded as B-type earthquakes having rather deep hypocenters. Relating these earthquakes with the volcanic phenomena, it is inferable that earthquake motion began at depths of about 10 km under Usu-san. Dome-like upheaval then occurred due to the upward movement of magma beneath the eastern foot of Usu-san, and shallow earthquakes were caused by the destruction of the earth's crust near the surface. With the approach of almost solidified magma to the earth's surface, the earth's crust near the surface was progressively destroyed resulting in the formation of B-type earthquakes. Finally, the magma may have been extruded by the pressure of steam derived from the magma. By the time the lava dome had protruded from a newly opened crater, the immediate subsurface structure in the vicinity of Shōwa-Shinzan had already been destroyed. Hence, the mountain body near the earth's surface gave only load resistance to the upward movement of magma. Excessive stress did not accumulate, and B-type earthquakes did not occur. However, earthquakes occurred frequently from a rather deep part of the lava-dome, due to the pressure on the bottom of the intruded magma. A report has been already published on the eruption of Usu-san, so in this paper, only the daily frequency of A-type and B-type earthquakes in Usu-san from June 1944 to March 1945 is described. The mode of changes of the ratio of daily frequency (F_{B+C}) of B-type (and C-type) earthquakes to the daily frequency (F_A) of A-type earthquakes accompanying the volcanic activity is shown in Figure 12. The writers must mention that it is evident from their investigation and from seismograms recorded at Sapporo and Muroran that all earthquakes which were recorded on and after December 27, 1943, were of A-type. B-type earthquakes were almost absent.

As is evident in Figure 12, the ratio $F_{B+C} + F_C/F_A$ gradually became larger in the general period June 1944 - March 1945. This change of the ratio confirmed the fact that the positions of hypocenters migrated toward the earth's surface. This indicates that the earthquake hypocenters migrated upward in accordance with the upward movement of magma. Stress which worked on the volcanic body migrated from a great depth to the earth's surface, and ultimately formed the lava-dome.

Beginning about two years prior to the development of Shōwa-Shinzan, precise levelling was conducted 30 times, and the development of Shōwa-Shinzan was measured in detail. It was particularly noticeable that the epicenters of B-type earthquakes migrated and were concentrated beneath the narrow upheaval area.

Thus, Usu-san is unprecedented in the activity which furnishes us with many valuable hints on the relation between the ascent and the eruptions of highly viscous lava, as has been proved by the detailed study of the mode of

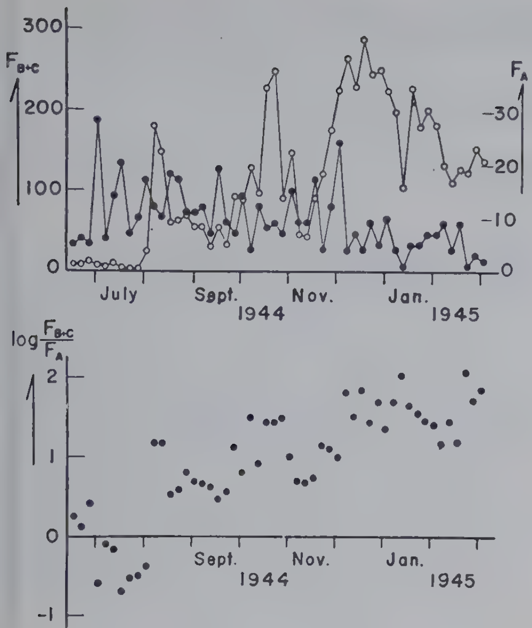


FIGURE 12. Comparison of the five days frequencies of the various types of earthquakes (A, B and C), which took place at the 1944-1945 activity of Volcano Usu.

The figure shows evidently that the shallow earthquakes (B and C) increased and contrarily the deeper earthquake (A) decreased both in accordance with the development of volcanic activity and the upward movement of viscous lava.

earthquake occurrence and the precise measurements of topographical changes.

In summary, this activity began with the occurrence of A-type earthquakes, which was followed by the increase of B-type earthquakes, indicating the gradual approach of the eruption. This activity constituted an important contribution to the study of predicting eruptions because this activity provided important information for predicting the time when an eruption will occur (such as the remarkable increase of earthquake frequency prior to the occurrence of eruption).

The pre-eruption phenomena of other volcanoes also will be referred to. According to past records, the activities of Krakatoa of 1883, (Royal Society, 1888), Mont Pelée of 1902 (Lacroix, 1904), Paricutin of 1943 (Gonzales and Foshq, 1947), Bezymianny of 1956 (Gorshkov, 1957), and Sakura-jima of 1914 (Omori, 1914-1922), were of grand scale, and in all of these cases the eruptions were ushered in by noticeable earthquakes. Judging from the extent of the area jarred by these earthquakes, it is considered that they were of A-type. However, thorough discussion of these earthquakes is impossible due to the scarcity of reports on seismometric observations made in the vicinity of the volcanoes at the time of activity, and particularly observations before the eruptions. Consequently the writers cannot confirm whether or not A-type earthquakes occurred, or if the eruptions were preceded by swarms of B-type earthquakes.

Concerning the activities of Asama Volcano for the last 30 years, though many large explosive eruptions have occurred the recent activity of the volcano has been of small scale when compared with the activity of the above volcanoes. Therefore, in this respect, it is not adequate to discuss them on an equal footing. However, when the eruptions of Asama Volcano are compared with other eruptions of the same magnitude (for example, Aso Volcano (Sassa, 1937), Sakura-jima, Kilauea, and Mihara-yama), the occurrence of A-type earthquakes at Asama Volcano is very rare.

Now that volcanological observatories provided with seismographs and other instruments have been established near the active volcanoes in Japan and in various other countries, in the near future data pertinent to these problems will become available.

CONCLUSION

In this paper, the hypocenters of earthquakes originating from volcanoes are discussed. Emphasis is placed on the depth of hypocenters of B-type earthquakes. It is also shown that particularly shallow earthquakes can be distinguished from those which originate from greater depth by the attenuation of amplitudes of earthquake motion with increasing epicentral distance. In addition, it is pointed out that when B-type earthquakes have the same epicenter, differing relations between earthquakes and eruptions is caused by slight differences of focal depth. On the other hand, the writers assert that the rare occurrence of deep A-type earthquakes originating beneath Asama Volcano as compared with other volcanoes is a peculiarity of Asama Volcano. The writers conclude also that a series of volcanic phenomena, i.e., the upward movement of the source of vibration energy, the destruction of the earth's surface, the occurrence of eruption, and the formation of a lava dome, is well illustrated by the seismic activity of Usu-san in 1943-1945. Particularly well illustrated was the gradual migration of the hypocenters from a depth of 10 km to the earth's surface, the upheaval of a small area, the commencement of outburst, and the formation of a lava-dome accompanied by A-type and B-type earthquakes.

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REFERENCES

Furumoto, S., (no date),: Volcano Letter (in Japanese).

__________, 1951: Bull. volcanol., ser. 2, no. 11, p. 45. (in Japanese).

Geophys. review: Seismol. bull., etc.

Gonzalez, J., and Foshag, W. F., 1947: Smithsonian rept. for 1946, p. 223.

Gorshkov, G. S., 1957, Abstract of reports, 11th general assembly, IUGG, p. 7.

Hagiwara, T., 1941, Bull. earthq. res. inst., no. 19, p. 323.

Japan Meteorological Agency: seismograms, courtesy Seismol. section (in Japanese).

Jones, A. E., 1935, Jour. Washington Acad. Sci., v. 25, p. 429.

Kizawa, T., 1957, Papers in meteor. and geoph., v. 8, p. 150.

Kuno, H., 1959: Bull. volcanol., ser. 2, no. 20, p. 37.

Lacroix, A., 1904: La montagne pelée et ses eruptions, p. 1.

Minakami, T., 1956: Bull. volcanol., ser. 2, no. 18, p. 39 (in Japanese).

__________, 1959, Bull. volcanol, ser. 2, no. 4, p. 104, (in Japanese).

Minakami, T., and Hiraga, S.: unpublished as of March 1960 (in Japanese).

Minakami, T., Hiraga, S., Uchibori, S., and Miyazaki, T.: Bull. volcanol., ser. 2, no. 4, p. 115 (in Japanese).

Minakami, T., Ishikawa, T., and Yagi, K., 1951: Bull. volcanol., ser. 2, no. 11, p. 45.

Minakami, T., Mogi, K., Hiraga, S., and Miyazaki, T., 1959: Bull. volcanol., ser. 2, no. 4, p. 77 (in Japanese).

Omori, F., 1912: Bull. imp. earthq. inv. comm., v. 6, p. 1.

__________, 1914: Ibid., v. 7, p. 1.

__________, 1914, (1922): Ibid., v. 8, p. 1.

Royal Society, 1888: THE ERUPTION OF KRAKATOA AND SUBSEQUENT PHENOMENA, p. 1.

Sassa, K., 1935: Mem. coll. sc. Kyoto. Imp. univ., ser. A., v. 18, p. 225.

__________, 1936: Ibid., v. 19, pp. 11 and 171.

Takahasi, R., and Nagata, T., 1939: Jour. seismol. soc. Jap., v. 11, p. 161 (in Japanese).

Notes on international scientific meetings

INTERNATIONAL COMMISSION FOR THE SCIENTIFIC EXPLORATION OF THE MEDITERRANEAN SEA, 17th ASSEMBLY, MONACO, DECEMBER 12-16, 1960

About 130 scientists attended the 27th Assem-
ly of the International Commission for the
cientific Exploration of the Mediterranean Sea,
eld in the Oceanographic Museum, Monaco,
rom December 12 through 16, 1960. An entire
ay was devoted to a discussion of the plans of
he French Commissariat à l'Energie Atomique
o dispose of radioactive wastes in the Mediter-
anean. Because of serious objections on ocean-
graphic basis as well as popular opposition,
he authorities agreed not to proceed with ex-
eriments without submitting proposals to a
Iational Committee on Oceanography for scien-
ific appraisal.

It was reported that the program to produce a
General Bathymetric Chart of the Mediterranean
ea" at a scale of 1:750,000, was now about 75
ercent complete.

The scientific papers presented at the assem-
ly will appear in the Rapport et Procés - Ver-
aux, of the commission, probably available
ext year. Of the about 125 papers presented
ome 15 percent were on geologic or geophysi-
al topics. They are as follows:

ORAMINIFERA OF THE SEDIMENTS OF THE LIGURIAN SEA, by G. Fierro (Italy; Istituto di Geologie, Univ. di Genova)

TUDY OF THE MOVEMENT AND MIGRATION OF THE LITTORAL DEPOSITS IN SHALLOW DEPTHS IN THE LIGURIAN SEA IN RELATION TO BATHYMETRY, TEXTURE, AND WAVE MOTION, by S. Conti and G. Fierro (Italy)

EOGRAPHICAL AND MORPHOLOGICAL ASPECTS OF THE VENICE LAGOON, by G. Morandini (Italy; Istituto di Geografia, Univ. di Padova)

NFLUENCE OF GEOMORPHOLOGICAL, HYDROPHYSICAL, AND BIOLOGICAL FACTORS ON THE SORTING OF SEDIMENTS IN THE DEPRESSIONS OF THE ADRIATIC, by S. Alfirević (Yugoslavia)

EOLOGIC-TECTONIC BASIS FOR SUBMARINE SPRINGS IN THE ADRIATIC, by S. Alfirević (Yugoslavia)

OMMUNICATION OF SOME FUNDAMENTAL OBSERVATIONS CONCERNING GRANULOMETRIC TECHNIQUES, by L. Amoureux (France; Mar. Biol. Sta., Roscoff)

IAGNETIC SURVEY OF SOUTHERN ITALY. C. Morelli (Italy)

MAJOR PHYSIOGRAPHIC AND STRUCTURAL FEATURES OF THE ADRIATIC ACCORDING TO THE NEW GENERAL CHART MADE FROM SURVEYS OF THE AZIO AND STAFETTA OF THE ITALIAN HYDROGRAPHIC OFFICE, by A. G. Segrè (Italy)

THE NEW BATHYMETRIC CHARTS OF THE CENTRAL MEDITERRANEAN PUBLISHED BY THE ITALIAN HYDROGRAPHIC OFFICE, by A. G. Segrè (Italy)

GEOLOGICAL COMMENT ON THE GRAVIMETRIC DATA FOR THE CONTINENTAL SHELF AROUND ITALY COLLECTED BY THE GEOPHYSICAL OBSERVATORY AT TRIESTE, by A.G. Segrè (Italy)

THE GRAVIMETRIC AND GEOLOGICAL SURVEY OF THE TUSCANY ARCHIPELAGO MADE IN 1955 ABOARD THE D.V. 408 OF THE ITALIAN HYDROGRAPHIC OFFICE, by A.G. Segrè (Italy)

ON THE MAGNETIC SURVEY OF THE TUSCANY ARCHIPELAGO (JULY - AUG 1959) by M. Giorgi (Italy; Consiglio Nazionale della Ricerche, Roma)

BASALTIC LAVA COLLECTED 38 MILES SOUTHEAST OF CAPE PALINURO (TYRRHENIAN SEA) ABOARD THE VEMA, by A. Rittman (Italy; Istituto Vulcanologico, Univ. di Catania)

GRAVIMETRIC SURVEY OF THE SUBMERGED EPICONTINENTAL PLATFORM AROUND ITALY, by A. Ciani, C. Gantar, and C. Morelli (Italy)

INTRODUCTION TO THE GRAVIMETRIC OBSERVATIONS OF THE MEDITERRANEAN: THEORETICAL PREMISE AND EXPERIMENTAL RESULTS OF THE CRUISE OF THE STAFETTA IN 1959, by A. Ciani, U. Flaischer, and C. Morelli (Italy)

SOME REMARKS ON A SERIES OF SEISMIC REFLECTION STUDIES IN THE GULF OF TUNIS, by P. Muraour (Tunisia)

TURBIDITY CURRENTS IN THE CANYONS OF THE GULF OF GENOA, by J. Bourcart (France)

PRESENTATION OF THE BATHYMETRIC CHART OF THE WESTERN MEDITERRANEAN, by J. Bourcart (France)

A PROPOSAL FOR STUDY OF THE CRUSTAL AND UPPER MANTLE STRUCTURE OF THE WESTERN MEDITERRANEAN BY SURFACE WAVE DISPERSION, by L. Knopoff and F. Press (United States)

REORGANIZATION OF THE SOVIET IGY COMMITTEE: A CIRCULAR BY N.V. SHEBALIN, SECRETARY OF THE SOVIET GEOPHYSICAL COMMITTEE, MARCH 20, 1961

The Interdepartmental Committee for the International Geophysical Year, sponsored by the Presidium of the Academy of Sciences of the U.S.S.R., widely known under the abbreviated name of the Soviet IGY Committee, was reorganized in February, 1961, into the Interdepartmental Geophysical Committee, sponsored by the Presidium of the Academy of Sciences of the U.S.S.R., with the abbreviated name of the Soviet Geophysical Committee. This committee is entrusted with all the tasks of coordination of complex researches in geophysics. It is also charged with the organization of scientific application of the IGY data, publication of these data, the regulation of the activity of the IGY World Data Center B, etc. The Soviet Geophysical Committee will act as the National Committee of the USSR in relationships with the International Union of Geodesy and Geophysics and as the IGY Committee for the Comité International de Géophysique. According to this reorganization to the former National Committee for Geodesy and Geophysics is discharged.

The Bureau of the Soviet Geophysical Committee consists of the President (Prof. V.V. Beloussov), three Vice-Presidents (Prof. J.D. Boulanger, Dr. G.I. Golyshev, Dr. K.T. Logvinov) and nine members of the Bureau, including Dr. N.V. Shebalin, Secretary of the Committee, and A.D. Povzner, Associate Secretary. The Soviet Geophysical Committee has 13 Sections: Geodesy, Seismology and Physics of the Earth's Interior, Meteorology and Physics of the Atmosphere, Geomagnetism and Earth Currents, Aurorae, Ionosphere, Solar Activity, Cosmic Rays, Oceanography, Scientific Hydrology, Glaciology, Volcanology, and Geochemistry. The Committee will have a number of Working Commissions for certain projects and complex problems, for instance: Working Commission on Upper Mantle (Chairman Prof. V.A. Magnitskiy); Working Commission on International Quiet Sun Year (Chairman Dr. N.V. Pushkov); Working Commission for Coordination of IGY Data Application (Chairman Dr. V.A. Troitskaya), etc. Each Commission consists of representatives from corresponding Sections. The Soviet Geophysical Committee has in all about 50 members.

In connection with the reorganization the Bulletin d'Information "International Geophysical Year" will be published under a new name: the "Geophysical Bulletin," starting from the next issue. The covers of the issues of the IGY scientific results series will be slightly changed in accordance with the new name of the Committee.

The Soviet Geophysical Committee is the lawful successor of the National Committee for Geodesy and Geophysics and of the Soviet IGY Committee.

Soviet Geophysical Committee, Molodezhnaya 3, Moscow B-296, U.S.S.R.

Reference Section

RUSSIAN AND EAST EUROPEAN GEOLOGIC ACCESSIONS OF THE LIBRARY OF CONGRESS

This section is devoted to a listing of selected geologic items appearing in the two publications of the Library of Congress; Monthly Index of Russian Accessions, and East European Accessions Index. These lists are intended as a means of indicating to researchers in the earth sciences some of the material most recently available for screening, further review, and translation. For this reason the lists do not include material now, or soon to be, published in English. Emphasis is placed on Russian material; the extent to which items from East European sources are listed depends on the country and language involved.

A major function of the AGI translations program is the screening of foreign literature for material that should be made available to the English-speaking scientist. Researchers who need such material are urged to review these lists and send us their recommendations for consideration by the editors; the translation needs of all geologists will be served better thereby.

MONTHLY INDEX OF RUSSIAN ACCESSIONS

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AKADEMIIA NAUK KAZAKHSKOI SSSR, Alma-Ata. [Basic ideas of N. G. Kassin on the geology of Kazakhstan; collected studies dedicated to the memory of Nikolai Grigor'evich Kassin, an Academician of the Academy of Sciences of the Kazakh S. S. R.] Osnovnye idei N. G. Kassina v geologii Kazakhstana; sbornik posviashchen svetloi pamiati akademika AN KazSSR Nikolaia Grigor'evicha Kassina. Alma-Ata, 1960. 420 p.

AKADEMIIA NAUK SSSR. Bashkirskii filial. Gorno-geologicheskii institut. [Devonian sediments in Bashkiria] Devonskie otlozheniia Bashkirii. Moskva.
Pt. 1. [Stratigraphy] Stratigrafiia. 1961. 250 p.

AMIRKHANOV, KH. I., S. B. BRANDT, and E. N. BARTNITSKII. [Radiogenic argon in minerals and rocks] Radiogennyi argon v mineralakh i gornykh porodakh. Predisl. D. I. Shcherbakova. Makhachkala, Akad. nauk SSSR, Dagestanskii filial, 1960. 200 p.

BOGOSLOVSKII, B. B. [Limnology] Ozerovedenie. [Moskva] Izd-vo Mosk. univ., 1960. 334 p.

EINOR, O. L. [Fundamentals of the geology of the U. S. S. R.] Osnovy geologii SSSR. [Kiev] Izd-vo Kievskogo univ.
Pt. 1. 1960. 335 p.

KUDELIN, B. I. [Principles underlying regional estimation of natural resources of underground waters] Printsipy regional'noi otsenki estestvennykh resursov podzemnykh vod. [Moskva] Izd-vo Mosk. univ., 1960. 343 p.

KUDYMOV, B. IA. [Spectral logging of boreholes; geochemical studies of sedimentary rocks] Spektral'nyi karotazh skvazhin; geokhimicheskie issledovaniia osadochnykh porod. Pod red. V. A. Sokolova. Moskva, Gos. nauchno-tekhn. izd-vo neft. i gorno-toplivnoi lit-ry, 1960. 60 p.

KUZ'MINSKAIA, G. [Black Sea] Chernoe more. [Krasnodar] Krasnodarskoe knizhnoe izd-vo, 1960. 56 p.

LARIONOV, A. K., and V. P. ANAN'EV. [Fundamentals of mineralogy, petrology, and geology] Osnovy mineralogii, petrografii i geologii. Moskva, Gos. izd-vo "Vysshaia shkola," 1961. 388 p.

LENINGRAD. GOSUDARSTVENNYI GIDROLOGICHESKII INSTITUT. [Index of Soviet literature on land hydrology, 1945-1950] Ukazatel' sovetskoi literatury po gidrologii sushi, 1945-1950 gg. Leningrad, Gidrometeor. izd-vo, 1960. 210 p.

LIUBIMOVA, E. L. [Kamchatka; physicogeographical study] Kamchatka; fiziko-geograficheskii ocherk. Moskva, Gos. izd-vo geogr. lit-ry, 1961. 189 p.

[METHODS AND RESULTS IN THE STUDY OF HYDROGEOLOGICAL AND ENGINEERING GEOLOGICAL CONDITIONS OF LARGE RESERVOIRS] Opyt i metodika izucheniia gidrogeologicheskikh i inzhenerno-geologicheskikh uslovii krupnykh vodokhranilishch. Pod red. G. S. Zolotareva, D. S. Sokolova i E. G. Chapovskogo. [Moskva] Izd-vo Mosk. univ.
Pt. 1. 1959. 175 p. diagrs, maps.

ORLOV, IU. A., ed. [Fundamentals of paleontology; manual in fifteen volumes for paleontologists and geologists of the U. S. S. R.] Osnovy paleontologii; spravochnik dlia paleontologov i geologov SSSR v piatnadtsati tomakh. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po geol. i okhrane nedr.
Vol. 7. [Polyzoa, Brachiopoda. Supplement: Phoronidea] Mshanki, brakhiopody. Prilozhenie: Foronidy. Otvet. red. T. G. Sarycheva. 1960. 342 p. plates.

PONOMAREV, A. I. [Methods for a chemical analysis of siliceous and carbonaceous rocks] Metody khimicheskogo analiza silikatnykh i karbonatnykh gornykh porod. Moskva Izd-vo Akad. nauk SSSR, 1961. 413 p.

RUKHIN, L. B., and E. V. RUKHINA. [Cretaceous deposits in the Fergana Valley; stratigraphy and lithology] Melovye otlozheniia Ferganskoi kotloviny; stratigrafiia, litologiia. [Leningrad] Izd-vo Leningr. univ., 1961. 161 p.

SIDORENKO, A. V., and O. I. LUNEVA. [Lithologic study of metamorphic formations] K voprosu o litologicheskom izuchenii metamorficheskikh tolshch. Moskva, Izd-vo Akad. nauk SSSR, 1961. 196 p.

SOLONENKO, V. P. [Studies of Eastern Siberia from the point of view of engineering geology] Ocherki po inzhenernoi geologii Vostochnoi Sibiri. Irkutsk, Irkutskoe knizhnoe izd-vo, 1960. 86 p.

STARIK, I. E. [The age of rocks and of the earth; based on radioactive data] Vozrast gornykh porod i zemli; po radioaktivnym dannym. Moskva, Izd-vo "Znanie," 1961. 31 p. (Vsesoiuznoe obshchestvo po rasprostraneniiu politicheskikh i nauchnykh znanii. Ser. 12, Geologiia i geografiia, no. 6)
[MICROFILM]

VLADIMIROV, L. A. [History of the study of runoff characteristics in mountain regions] K istorii issledovanii zakonomernostei stoka v gornykh oblastiakh. Tbilisi, Izd-vo Akad. nauk Gruzinskoi SSR, 1960. 145 p.

VRUBLEVSKII, V. I. [Determination of the mechanical properties of rocks in industry] Opredelenie mekhanicheskikh svoistv gornykh porod v proizvodstvennykh usloviiakh. Kiev, Gos. izd-vo tekhn. lit-ry USSR, 1961. 86 p.

ZHVANIIA, D. G. [Plates of color designations for geological maps of various scales; geological legend] Tablitsy tsvetnykh oboznachenii dlia geologicheskikh kart raznykh masshtabov (geologicheskaia legenda). Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po geol. i okhrane nedr, 1960. 5 p. 58 plates (in portfolio).

MOSKOVSKOE OBSHCHESTVO ISPYTATELEI PRIRODY. Geograficheskaia sektsiia. [Problems of indicative geobotany] Voprosy indikatsionnoi geobotaniki. Pod red. S. V. Viktorova. Moskva, 1960. 110 p. [With summaries in English.]

TEIFEL', V. G. [Spectrophotometry of the moon's surface; author's abstract of the dissertation for the degree of candidate of physical and mathematical sciences] Spektrofotometriia poverkhnosti luny; avtoreferat dissertatsii na soiskanie uchenoi stepeni kandidata fiziko-matematicheskikh nauk. Leningrad, Glav. astronomicheskaia observatoriia, 1960. 9 p.

AKADEMIIA STROITEL'STVA I ARKHITEKTURY SSSR. Institut organizatsii, mekhanizatsii i tekhnicheskoi pomoshchi stroitel'stvu. [Earthwork operations under winter conditions] Proizvodstvo zemlianykh rabot v zimnikh usloviiakh; spravochnoe posobie. Moskva, Gos. izd-vo lit-ry po stroit., arkhit. i stroit. materialam, 1961. 149 p.

AKUTIN, G. K. [Mining in soft compressible soils by packing them with energy from blasting] Provedenie vyrabotok v miagkikh szhimaemykh gruntakh uplotneniem ikh energiei vzryva. Kiev, Izd-vo Akad. nauk USSR, 1960. 94 p.

AL'BOV, M. N. [Secondary zoning in gold deposits of the Urals] Vtorichnaia zonal'nost' zolotorudnykh mestorozhdenii Urala. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po geol. i okhrane nedr, 1960. 214 p.

AVRUTSKII, A. L., and others. [Handbook for core drillers] Spravochnik mastera kolonkovogo bureniia. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po gornomu delu, 1960. 528 p.

BEREZOVSKII, B. I. [Some characteristics of construction under conditions of the Far North] Nekotorye osobennosti stroitel'stva v usloviiakh Krainego Severa. Moskva, Gos. izd-vo lit-ry po stroit., arkhit. i stroit. materialam, 1960. 126 p.
[MICROFILM]

BILYK, O. D., and others. [Facies and paleogeography of Jurassic sediments in the oil- and gas- bearing area of the eastern Ukraine] Fatsii i paleogeografiia iurskikh otlozhenii Vostochno-Ukrainskogo gazoneftenosnogo basseina. Khar'kov, Izd-vo Khar'kovskogo gos. univ., 1960. 71 p.

BLOKHA, E. E., and S. L. ALEKSEEV. [Surveying and geology in mining enterprises] Marksheidersko-geologicheskaia sluzhba na gornykh predpriiatiiakh. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po gornomu delu, 1960. 89 p. (Bibliotechka molodogo shakhtera)

BOK, I. I., and A. V. PARSHIN. [Mineral resources in Kazakhstan] Poleznye iskopaemye Kazakhstana. Alma-Ata, Izd-vo Akad. nauk Kazakhskoi SSR, 1961. 50 p.

BUIALOV, N. I., and P. P. ZABARINSKII. [Prospecting for oil and gas fields] Poiski i razvedka neftianykh i gazovykh mestorozhdenii. Moskva, Gos. nauchno-tekhn. izd-vo neft. i gorno-toplivnoi lit-ry, 1960. 450 p

CHANISHVILI, V. F. [Development of manganese mining in Georgia] Razvitie margantsevoi promyshlennosti v Gruzii. Tbilisi, Izd-vo Akad. nauk Gruzinskoi SSR, 1960. 564 p. [In Georgian.]

FERSMAN, A. E. [Studies on the history of stone] Ocherki po istorii kamnia. Moskva, Izd-vo Akad. nauk SSSR.
Vol. 2. 1961. 370 p.

[FULL USE OF CHROMITES AND LIMONITES FROM THE SEROV DEPOSIT] Kompleksnoe ispol'zovanie burokhromistykh rud Serovskogo mestorozhdeniia. Sverdlovsk, TSentr. biuro tekhn. informatsii, 1959. 158 p. (Metallurgiia)

IAKUBOVICH, A. L. [Radiometric prospecting apparatus] Poiskovo-razvedochnaia radiometricheskaia apparatura. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po geol. i okhrane nedr, 1960. 205 p.

IAKZHIN, A. A. [Prospecting for uranium deposits] Poiski i razvedka uranovykh mestorozhdenii. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po geol. i okhrane nedr, 1961. 479 p.

KOVSHULIA, O. A. [Russian-Ukrainian mining dictionary] Rosiis'ko-ukrains'kyi hirnychyi slovnyk. 20 000 terminiv. Kyiv, Vyd-vo Akad. nauk URSR, 1959. 271 p.
(NN)

LITVINOV, N. N. [New mine surveying equipment] Novoe gornorazvedochnoe oborudovanie. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po geologii i okhrane nedr, 1959. 29 p.

[MINING HANDBOOK] Spravochnik po gornorudnomu delu. Red. kollegiia: A. M. Terpigorev i dr. [Izd. 2.] Moskva, Gos. nauchno-tekhn. izd-vo lit-ry.
Vol. 2. [Underground workings] Podzemnye raboty. Nauchn. red. A. M. Terpigorev i R. P. Kaplunov. 1961. 855 p.

MOSCOW. VSESOIUZNYI NAUCHNO-ISSLEDOVATEL'SKII INSTITUT MINERAL'NOGO SYR'IA. Otdel nauchno-tekhnicheskoi informatsii. [Drilling auger holes; drilling practices under various geological conditions] Shnekovoe burenie; iz opyta prokhodki skvazhin v razlichnykh geologicheskikh usloviiakh. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po geol. i okhrane nedr, 1960. 106 p.

OVCHARENKO, F. D. [Hydrophilic properties of clays and clay minerals] Gidrofil'nost' glin i glinistykh mineralov. Kiev, Izd-vo Akad. nauk USSR, 1961. 290 p.

RUSSIA (1923- U. S. S. R.) Glavnoe upravlenie geodezii i kartografii. [Directions for topographical surveys at scales of 1:10,000 and 1:25,000] Nastavlenie po topograficheskim s"emkam v masshtabakh 1:10 000 i 1:25 000. Izd. 3., ispr. i dop. Moskva, Izd-vo geodez. lit-ry.
Pt. 1. [Field work] Polevye raboty. 1960. 162 p.

SALOV, I. N. [Building materials (sand, gravel, and clay) of Smolensk Province] Stroitel'nye materialy (peski, gravii i gliny) Smolenskoi oblasti. Smolensk, Smolenskii kraevedcheskii nauchno-issl. in-t, 1960. 199 p.

SHATSOV, N. I., and others. [Drilling oil and gas wells] Burenie neftianykh i gazovykh skvazhin. Pod obshchei red. N. I. Shatsova. Moskva, Gos. nauchno-tekhn. izd-vo neft. i gorno-toplivnoi lit-ry, 1961. 666 p.

TSYTOVICH, N. A., I. N. VOTIAKOV, and V. D. PONOMAREV. [Methodological recommendations on the investigation of the settling of thawing ground] Metodicheskie rekomendatsii po issledovaniiu osadok ottaivaiushchikh gruntov. Moskva, Izd-vo Akad. nauk SSSR, 1961. 51 p.

VOROPINOV, V. S. [Siberian gypsum] Sibirskii gips. [Irkutsk] Irkutskoe knizhnoe izd-vo, 1960. 62 p.

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BULGARIA

Bulgarsko geologichesko druzhestvo. SPISANIE. REVIEW. Sofiia. [Bulletin issued by the Bulgarian Geological Society; with English, French, or German summaries. Three no. a year]

Vol. 21, no. 2, 1960.

IAranov, D. Cross depressions in the Rhodope-Anatolia anticline and their metallogenetic significance. p. 1.

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CZECHOSLOVAKIA

HANZELKA, JIRI. Mezi dvema oceany. [2. vyd.] Praha, Orbis, 1961. 351 p. (Edice Poznani sveta) [Between two oceans. 2d ed. illus. (part col.), fold. col. map, bibl., glossary, notes]

KLIMA, IVAN. Mezi tremi hranicemi. [Vyd. 1.] Praha, Ceskoslovensky spisovatel, 1960. 207 p. (Zivot kolem nas, sv. 2) [Surrounded by three borders; a travel diary. 1st ed. illus., map]

PETISKA, EDUARD. Mezi dvema rekami; navsteva v Polabi. Ilustroval Vilem Plocek. [1. vyd.] Praha, Statni nakl. detske knihy, 1960. 113 p. (Obrazky z domova, sv. 3) [Between two rivers; a visit to the Elbe River valley (for readers 11 years old and over). 1st ed. illus.]

CASOPIS PRO MINERALOGII A GEOLOGII. (Ceskoslovenska spolecnost pro mineralogii a geologii pri Ceskoslovenske akademii ved) Praha. [Journal issued by the Czechoslovak Society of Mineralogy and Geology, Czechoslovak Academy of Sciences; with English, German, and Russian summaries. Quarterly]
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Obrhel, J. The flora of the Srbsko beds (Givetian) in the Devonian of central Bohemia. In German. p. 7.

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STUDIA GEOPHYSICA ET GEODAETICA. (Ceskoslovenska akademie ved. Geofysikalni ustav) Praha. [Journal on geophysics, meteorology, climatology, and geodesy issued by the Geophysical Institute, Czechoslovak Academy of Sciences. In English, French, German, and Russian with summaries in a language different from that of the article. Two no. a year]

Vol. 5, no. 2, 1961.
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Kolbenheyer, T. Contribution to the theory of gravitation fields of homogenous and nonhomogenous infinite prisms. In Russian. p. 108.

DUDEK, ARNOST. Granodioritove lomy v okoli Blatne. Arnost Dudek, Ferry Fediuk. [1. vyd.] Praha, Nakl. Ceskoslovenske akademie ved, 1960. 58 p. (Geotechnica; sbirka praci z prakticke geologie, sv. 30) [Granodiorite quarries in the environs of Blatna. 1st ed. German summary. illus., maps (part fold.), bibl., tables]

Ceskoslovenska akademie ved. Hornicky ustav. SBORNIK PRACI. Praha. [Papers issued by the Mining Institute, Czechoslovak Academy of Sciences]

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VODOHOSPODARSKY CASOPIS. (Slovenska akademia vied) Bratislava. [Journal on water resources economy and hydraulic engineering issued by the Slovak Academy of Sciences; with English, French, German, and Russian summaries. Quarterly]

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ESTONIA

Eesti NSV Teaduste Akadeemia. Eesti Geograafia Selts. AASTARAAMAT. Tallinn. [Annals of the Estonian Geographical Society, Estonian Academy of Sciences. In Estonian and Russian with English, Estonian, German, and Russian summaries]

1959 (published '60).
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BANYASZATI LAPOK. (Magyar Banyaszati es Kohaszati Egyesulet) Budapest. [Journal on prospecting and mining issued by the Hungarian Mining and Metallurgic Society. Includes a supplement: Koolaj, on crude oil production. Monthly]
Recurrent features: Foreign news; News from the Society; Book reviews.

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SZAFEROWA, JANINA. Anatomical investigation on fossil fruits of the genus Caprinus in Poland. Badania anatomiczne nad kopalnymi owocami rodzaju Caprinus w Polsce. Krakow, 1961. 33 p. (Acta palaeobotanica, v. II, nr. 1) [In English with Polish summary. illus., plates, map, bibl., diagrs., tables]

BIULETYN PERYGLACJALNY. (Lodzkie Towarzystwo Naukowe) Lodz. [Papers on the geology of the glacial epoch, chiefly in Poland, issued by the Lodz Society of Science. In English, French, German, Italian, Polish, or Russian with English, French, Polish, or Russian summaries]

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ZASOPISMO GEOGRAFICZNE. (Polskie Towarzystwo Geograficzne) Wroclaw. [Issued by the Polish Geographical Society; with French summaries. Quarterly]

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CEMENT, WAPNO, GIPS. Warszawa. [Publication on adhesives in the building industry issued by Building and Architectural Publications. Includes a supplement: Przeglad Bibliograficzny Materialow Wiazacych, bibliography on adhesives. Monthly]

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Nielubowicz, R. Remarks on the stratigraphy and petrography of some Miocene gypsum layers in the western zones of the sub-Carpathian depression. p. 68.

Krakow. Akademia Gorniczo-Hutnicza. PRZEGLAD NAUKOWO-TECHNICZNY. SERIA G. Krakow. [Papers on mining engineering issued by the Academy of Mining and Metallurgy in Krakow]

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ol. 7, no. 3, Mar. 1961.

Depowski, S. The possibility of geophysical prospecting in the Carpathian Flysch. p. 51.

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REVISTA MINELOR. (Asociatia Stiintifica a Inginerilor si Tehnicienilor din Rominia al Ministerului Industriei Grele, Directia Generala Miniera, si Ministerul Industriei Petrolului si Chimie, Directia Exploatarilor Miniere) Bucuresti. [Publication on mining and related industries issued by the Scientific Association of Engineers and Technicians of Rumania at the Ministry of Heavy Industry, General Direction of Mining, and the Ministry of the Petroleum and Chemical Industries, Direction of Mine Operation; with English, French, German, and Russian summaries. Monthly]

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Polsak, A. Contribution to the knowledge of hydrogeological relations in the vicinity of the Plitvice Lakes. p. 315.

Srpska akademija nauka. Geografski institut. ZBORNIK RADOVA. Beograd. [Papers issued by the Geographic Institute, Serbian Academy of Sciences; with French summaries]

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ELEKTROPRIVREDA. (Zajednica jugoslovenske elektroprivrede) Beograd. [Journal issued by the Yugoslav Electricity Union; with English and French summaries. Monthly]

Recurrent features: Bibliography; Questions and answers; News from domestic electric enterprises and institutions.

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The following announcement appears on the cover of Volume 10, Number 8, August 1961.

The next two issues of the *East European Accessions Index* will be bimonthly. With the issuance of the November-December issue, the *Index* will cease publication. Its compilation and publication have been financed with funds transferred to the Library of Congress from other Government agencies which are withdrawing this support at the end of the calendar year.

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The Library of Congress does not currently print the translated table of contents of the periodicals indexed in the Monthly Index of Russian Accessions. By arrangement with the Library of Congress its manuscript translated tables of contents are scanned by the IGR staff for titles of potential translation interest to geologists Although this arrangement requires a different format, and the reporting of each Monthly Index's contents over two or more issues of IGR, it is assumed that this additional coverage is desirable and used. Suggestions for improving the service will be welcome.--M. R.

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- Symmetry properties of energy zones in crystals with the chalcopyrite structure. V.A. Chaldyshev, V.N. Pokrovskii. pp. 173-181.
- Geomagnetic effect of the burst of the Tunguska meteorite. G.F. Plekhanov and others. pp. 236-237.

Trudy Geol. muz. AN SSSR. Akademiia nauk SSSR. Geologicheskii muzei. Trudy [Academy of Sciences of the U.S.S.R. Geological Museum. Transactions]. no. 3, 1960.

- Ordovician and Silurian in the western slope of the Polar Urals. V.V. Markin.

Zhur. strukt. khim. Zhurnal strukturnoi khimii [Journal of Structural Chemistry] Vol. 1, no. 1 May-June 1960.]

- Second chapter in the crystallochemistry of silicates. N.V. Belov. pp. 39-50.
- Application of the electronic paramagnetic resonance method to the study of the molecular structure of coals. N.N. Tikhomirova, I.V. Nikolaeva, V.V. Voevodskii. pp. 99-102.

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- Snow drifts around semicircular cylindrical obstacle V.A. Voitsenia, A.K. Nikitin. pp. 157-167.

Vest. AN Kazakh. SSR. Akademiia nauk Kazakhskoi SSR, Alma-Ata. Vestnik [Academy of Sciences of the Kazakh S.S.R. Journal, Vol. 16, no.10, Oct. 1960.

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- Courses for a radical solution of the problem of using Ekibastuz coal. A.B. Rezniakov, E.P. Bogdanov. pp. 38-45.
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- New species of Myriophyllum from middle Quaternary sediments of the northern Tien Shan. V.S. Kornilova. pp. 101-102.

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Gaz. prom. Gazovaia promyshlennost' [Gas Industry]. Vol. 5, no. 11, November, 1960.

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Geol. mest. red. elem. Geologiia mestorozhdenii redkikh elementov [Geology of Rare-Element Deposits]. no. 8, 1960.

Geology of rare metal deposits. No. 8: Geochemical characteristics of scandium and types of its deposits. V. V. Shcherbina.

Nauk. zap. Nauk.-Pryrod. muz. AN URSR. Akademiia nauk URSR, Kiev. Naukovo-pryrodoznavchyi muzei. Naukovi zapysky [Academy of Sciences of the Ukrainian S. S. R. Scientific Museum of Natural History. Studies]. In Ukrainian. no. 8, 1960.

Mollusk fauna of Transcarpathia [with summary in English]. V. I. Zdun. pp. 83-95.
Studies on lower Devonian pteraspids of Podolia [with summary in English]. P. P. Balabai. pp. 124-133.
Lithological and faunistic characteristics of lower Oligocene deposits in the Uzh-Latoritsa-Vecha interfluve [with summary in English]. F. P. Temniuk. pp. 134-140.

Razved. i okh. nedr. Razvedka i okhrana nedr [Prospecting and Conservation of Mineral Resources]. Vol. 26, no. 10, October, 1960.

Granites containing microlites are a new promising type of deposits of tantalum. A. A. Beus, A. A. Sitnin. pp. 1-4.
Experimental determination of the minimum volume of a sample taken from diamond-bearing kimberlites. IU. F. Gritsenko. pp. 5-15.
Selecting the scale of topographic maps for use in mineral prospecting. D. N. Fialkov. pp. 15-17.
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Possibilities of geophysical methods in rare metal carbonatite prospecting. G. S. Vakhromeev. pp. 25-28.
Possibilities of electric prospecting in permafrost. V. S. IAkupov. pp. 29-32.
Determining ground water reserves in fluvoglacial and alluvial plains. N. N. Bindeman. pp. 33-39.
Hydrogeological investigations in ore prospecting. K. A. Bolatbaev. pp. 40-41.
Increasing the efficiency of geological studies in deep-lying complex metal prospecting. V. M. Volkov, I. T. Sakharov. pp. 41-42.
Reducing the cross section of trenches. V. F. Bochkarev, E. L. Koblents. pp. 46-48.
Consolidation and dissemination of progressive practices in the Krivoy Rog Basin Geological Trust. P. E. Sidorchuk, Z. I. Ivanovskaia. pp. 49-51.
Mechanization and automation of geological prospecting is an important factor in the prevention of accidents. L. IU. Parts. pp. 53-54.
Radiation protection when using neutron logging methods. R. S. Belova, I. I. IAnkovskii. pp. 54-55.
Sessions in the Collegium of the Ministry of Geology and Preservation of Mineral Resources of the U. S. S. R. pp. 58-61.

Torf. prom. Torfianaia promyshlennost' [Peat Industry]. Vol. 37, no. 7, 1960.

Hollow punch for frozen ground used in driving down piles. D. P. Ivanov. pp. 31-32.
Peat deposits in the Bulgarian People's Republic and their exploitation. p. 35.

Trudy Geog. ob-va Gruz. SSR. Geograficheskoe obshchestvo Gruzinskoi SSR. Trudy [Geographic Society of the Georgian S. S. R. Transactions]. no. 5, 1959.

Regularity in the development and vertical distribution of exogenous processes in relief types and forms on the territory of Georgian S. S. R. [in Georgian with summary in Russian]. A. N. Dzhavakhishvili. pp. 5-14.

Current geomorphological processes in the eastern part of the Akhaltsikhe depression [in Georgian with summary in Russian]. S. N. Nemanishvili. pp. 16-25.
Landslides on the northeastern slope of Gombori Range and measures for their control [in Georgian with summary in Russian]. G. Z. Changashvili. pp. 27-40.
New data on the movement of mud and stone flows. K. R. Begishvili. pp. 41-54.
Geomorphology of the karstic landform of the Bzyb' Range [in Georgian with summary in Russian]. Sh. IA. Kipiani. pp. 55-95.
On the age problem of high terraces along the ravine of the middle Rioni River (Nizhnyaya Racha) [in Georgian with summary in Russian]. D. V. TSereteli. pp. 97-104.
Terraces of the Kura River in the Tiflis vicinity [in Georgian with summary in Russian]. I. E. Dzhibladze. pp. 105-117.
Influence of tectonic structures in the relief formation of the Kvirila River Basin. [in Georgian with summary in Russian]. Z. K. Tintilozov. pp. 119-129.
On the problem of the origin of the Krestovyy and Bursachirskiy passes [in Georgian with summary in Russian]. I. S. Apkhazava. pp. 131-136.
Geomorphology of the karstic landform of the Arabika — Akh-Ag (Gagry) Range [in Georgian with summary in Russian]. Sh. IA. Kipiani. pp. 137-172.

[Trudy] Inst. geol. nauk AN URSR. Ser. Geotek. i geofiz. Akademiia nauk URSR, Kiev. Instytut geologichnykh nauk. [Trudy]. Seriia geotektoniky i geofizyky [Akademy of Sciences of the Ukrainian S. S. R. Institute of Geological Sciences. (Transactions). Series in Geotectonic Geophysics]. In Ukrainian. no. 4, 1958.

Physical properties of rocks in the southwestern and southern regions of the European part of the U. S. S. R. V. B. Sollogub.

Trudy VSEGEI. Leningrad. Vsesoiuznyi geologicheskii institut. Trudy [All-Union Geological Institute. Transactions]. no. 32, 1960

Geology of the Sarysu-Balkhash-Nura watershed. M. I. Aleksandrova and others. pp. 7-126.
Distribution of complex metal deposits in the Sarysu-Balkhash-Nura watershed. A. S. Velikii, I. I. Kniazev, A. S. Kumpan. pp. 129-203.

Uzb. geol. zhur. Uzbekskii geologicheskii zhurnal [Uzbek Geological Journal]. no. 5, 1960.

Some results of biogeochemical (geobotanical) research in western Uzbekistan. I. Kh. Khamrabaev, R. M. Talipov. pp. 3-11.
Tectonic pattern of the Kara-Kalpak A. S. S. R. as an indicator of oil and gas occurrences. A. G. Babaev, IU. A. Fedotov. pp. 12-21.
Some petrochemical and geochemical features of upper Paleozoic effusive rocks in the right bank of the Angren River. V. A. Khorvat, P. I. Salov. pp. 23-33.
Authigenic minerals of Tertiary continental sediments in Central Asia. N. I. Gridnev. pp. 34-44.
Chrompicotite and fuchsite from the central Kyzyl Kum. Kh. Rakhmatullaev. pp. 45-49.
Trace elements in skarn-ore and hydrothermal deposits of the middle Pskem and Ugam Rivers. K. Urunbaev. pp. 50-62.
History of relief formation of the Sandalash Basin. M. M. Mamtkulov. pp. 63-72.
Kyrktau Plateau as a classical example of karst topography. N. A. Gvozdetskii. pp. 73-81.
Tectonic basis for the classification of petrographic provinces. N. A. Beliaevskii. pp. 82-88.
Determination of the specific gravity of minerals by the microvolume method. IA. S. Eshpulatov. pp. 89-90.

Zav. lab. Zavodskaia laboratoriia [The Factory Laboratory]. Vol. 26, no. 11, 1960.

Method of determining potassium from the natural radioactivity. N. I. Pavlova, T. M. Khrenkova. pp. 1201-1202.

Zemledelie [Agriculture]. Vol. 8, no. 12, December 1960.

Large-scale soil investigations. I. A. Chirvinskii. pp. 83-86.

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Avt. dor. Avotomobil'nye dorogi [Highways] Vol. 23, no. 12, December 1960.

Take into account the characteristics of loess soils. V. M. Dadykin. pp. 11-12.
Special problems in conducting earthwork on morainic soils. V. F. Osetrov. p. 12.
Electric geophysical explorations in road surveying. G. Titarenko. p. 18

Dokl. AN Arm. SSR. Akademiia nauk Armianskoi SSR, Erivan. Doklady [Academy of Sciences of the Armenian S. S. R. Reports]. Vol. 31, no. 4, 1960.

Effect of a compacting load on the deformation properties of clay soils under shear. S. R. Meschian. pp. 211-217.

Geod. i kart. Geodeziia i kartografiia [Geodesy and Cartography]. no. 10, October 1960.

Use of departmental materials in identifying more precisely the characteristics of wells and springs. R. I. Vol'pe. pp. 35-36.
Topographical surveys for the estimation of mineral resources. pp. 48-52.
Considerations on the project of the new instruction for geodetic operations in geophysical surveying. A. S. Kronrod. pp. 53-59.
Economic map of a province. Z. I. Martynova. pp. 59-60.

No. 11, November 1960.

Experimental and practical work in interpreting aerial color photographs. A. A. Shirokov, V. I. Lebedev, K. G. Kovalev. pp. 34-35.
Geomorphological map of the U. S. S. R. I. S. Brykovskaia. pp. 58-60.

Geol. mest. red. elem. Geologiia mestorozhdenii redkikh elementov [Geology of Rare-Element Deposits]. no. 7, 1960.

Determining the process of formation of pegmatite bodies. I.N. Timofeev. pp. 5-34.
Mechanism of formation of cavities filled with pegmatites and the structure of pegmatite deposits. G.G. Rodionov. pp. 35-57.
Characteristics of the replacement of enclosing rocks at the early stages of the formation of pegmatites. I.N. Timofeev. pp. 57-75.
Characteristics of the replacement of enclosing rocks at the later stages of the formation of pegmatites. A.S. Nazarova. pp. 75-89.
Concluding remarks. A.I. Ginzburg. pp. 90-93.
Bibliography on structures of pegmatite deposits and the mechanism of formation of pegmatite bodies. pp. 94-98.

eofiz. razved. Geofizicheskaia razvedka [Geophysical Prospecting]. no. 2, 1960.

Method of processing seismic prospecting data. A.I. Khramoi. pp. 3-11.
Correlation of refractions in the zone of erosion and thinning of strata B.I. IUrchenko. pp. 11-16.
Developing and introducting methods of processing and interpreting gravity prospecting data. B.A. Andreev. pp. 16-30.
Subsurface gravimetric investigations in copper-pyrite deposits of the Central Urals. E.A. Mudretsova. pp. 31-59.
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Simplified apparatus for amplitude-phase measurements of the low-frequency electromagnetic field. B.S. Svetov, IU. A. Turchin. pp. 68-87.
Small-size field seismoscope for measuring the speed of elastic waves. P.G. Gil'bershtein, I.A. Koloskov. pp. 87-99.
Designing perforated models of seismic media. P.G. Gil'bershtein. pp. 100-119.
Improving the radio circuit for recording the instance of explosion. A.A. Fedin. pp. 119-120.

form. sbor. VSEGEI. Leningrad. Vsesoiuznyi geologicheskii institut. Informatsionnyi sbornik [All-Union Geological Institute. Information Bulletin]. no. 6, 1959.

Ordovician and Silurian stratigraphy and facies of the western zone of the Northern Urals. K.P. Evseev. pp. 3-11.
Unconformity of Polyzoa and Foraminifera in the cross section of lower Permian sediments in the Pechora Basin. G.I. Baranova. pp. 13-17.
Palynological basis for Stratigraphic correlation of Triassic sediments in the northeastern part of the Turgay Gates. G.M. Romanovskaia. pp. 19-29.
Find of the Paleocene foraminiferal complex with Cibicides lectus Vassilenko in the northeastern and eastern parts of the Turgay Gates. I.M. Aizenshtat. pp. 31-35.
Devonian stratigraphy of the Kyzyl-Shin Basin (Gornyy Altai). E.N. IAnov. pp. 37-45.
Pre-Cambrian and Cambrian stratigraphy of the Artemovskiy region (Eastern Sayans). A.Z. Konikov. pp. 47-53.
Middle Devonian Azyrtal series in the Minusinsk Basin. L.G. Maimina, V.S. Meleshchenko, E.N. IAnov.
Certain common features in the Devonian stratigraphy of the Uymen' Depression and Minusinsk Basin. IU. S. Maimin. pp. 63-70.
Correlation of the Sanchugovka (Boreal) sea drift and the Yenisey glaciation as revealed by the stratigraphic scale. V.A. Zubakov. pp. 71-75.
Basic problems of the geology of the right bank of the Greater Yenisey in the Uyuk-Sistig-Khem interfluve. V.G. Bogomolov. pp. 77-85.
Stratigraphy of sediments in the upper layers of the Quaternary system of the Pur-Nadym watershed and the southern Tazovskiy Peninsula. F.A. Aliavdin. pp. 87-93.
Line of maximum extent of the Jurassic Sea on the Siberian Platform. N.N. Tazikhin. pp. 95-98.
Pre-Cambrian stratigraphic scale of the Uda-Zeya region. V.N. Moshkin. pp. 99-105.

IUn. tekh. IUnyi tekhnik [Young Technician]. Vol. 5, no. 10, October 1960.

Studying the areographic map. R. Dvoinikov. pp. 22-25.
What is inside? A. Dorokhov. pp. 26-29.
Water vapors found on Venus. pp. 31.
Drift of continents V. Magnitskil. pp. 52-54.

Izv. AN SSSR. otd. tekh. nauk. Mekh. i mashinostr. Akademiia nauk SSSR. Izvestiia. Otdelenie tekhnicheskikh nauk. Mekhanika i mashinostroenie [Academy of Sciences of the U. S. S. R. Bulletin. Department of Technological Sciences. Mechanics and Machine Building.] no. 6, Nov.-Dec. 1960.

Unsteady flow of underground water in a nonuniform water-bearing layer. LiuTS'ŭ-ch-ŭn. pp. 127-129.
Determination of the parameters of a layer of fractured rocks based on the pressure build-up curve considering the inflow after a well has been shut in. Ban Akos. pp. 129-133.
Formation of irreversible fractures in rocks. IU. P. Zheltov. pp. 52-56.

Izv. vys. ucheb. zav.; gor. zhur. Russia (1923 - U. S. S. R.) Ministerstvo vysshego i srednego spetsial'nogo obrazovaniia. Izvestiia vysshikh uchebnykh zavedenii; gornyi zhurnal [Ministry of Higher and Secondary Specialized Education. Bulletin of the Institutions of Higher Learning; Mining Journal]. no. 11, 1960.

Classification and terminology of underground coal-mining systems. D.F. Borisov. pp. 31-38.
Problems of rock permeability. I.I. Vakhrameey. pp. 73-86.

Izy. vys. ucheb. zav.; mat. Russia (1923- U. S. S. R.) Ministerstvo vysshego i srednego spetsial'nogo obrazovaniia. Izvestiia vysshikh uchednykh zavedenii; matematika [Ministry of Higher and Secondary Specialized Education. Bulletin of the Institutions of Higher Learning; Mathematics]. no. 3, 1960.

Problem pertaining to the breakthrough of edge water to the gallery of a well. IA. Chilap. pp. 241-255.

Kora vyvetr. Kora vyvetrivaniia; geologiia, mineralogiia, protsessy vyvetrivaniia, mineral'nye mestorozhdeniia [Weathering Zone; Geology, Mineralogy, Processes of Weathering, Mineral Deposits]. no. 3, 1960.

Mineralogy of bismuth in the oxidation zone. F.V Chukhrov, V.M. Senderova,

L.P. Ermilova. pp. 5-25.
Coronadite and cryptomelane from the Mayskiy complex ore deposit in central Kazakhstan. I.A. Rukavishnikova, T.A. IAkovlevskaia, A.I. Pokrovskaia. pp. 26-32.
Nickeliferous magnetite in silicate-nickel deposits. I.I. Ginzburg. pp. 33-38.
Manganese minerals in the weathered surface of the Buryktal'skiy ultrabasite massif. K.K. Nikitin. pp. 39-55.
"Nickelmelane" and "cobaltmelane". I.I. Ginzburg. pp. 56-66.
Twins of cerussite from the Kaskaygyr deposit in central Kazakhstan. I.A. Rukavishnikova, V.V. Kolesnikov, S.K. Arbuzova. pp. 67-71.
Supergene nickeliferous magnetite. I.I. Edel'shtein. pp. 72-73.
New data on the mineralogy of the oxidation zone in the Akchagyl deposit in central Kazakhstan. I.V. Vitovskaia. pp. 74-116.
Minerals in the oxidation zone of the Blyava deposit. L.D. German. pp. 117-135.
Minerals in the oxidation zone of the Alaygyr lead deposit in central Kazakhstan. K.M. Mukanov. pp. 136-151.
High-grade iron ores in the Mikhaylovskiy deposit of the Kursk Magnetic Anomaly. V.P. Rakhmanov. pp. 152-179.
"Ocherlike" shales in the upper series of the Krivoy Rog. D.I. Ishchenko. pp. 180-184.
Relationship between the high-grade iron ore deposits of the Saksagan' band and the oxidized zone. D.I. Ishchenko, V.M. Zaruba. pp. 185-189.
Oxidation zone of high-grade iron ores of the Ingulets-type in the Krivoy Rog Basin. IU. G. Gershoig. pp. 190-202.
Geology and conditions determining the formation of high-grade ores in the Mikhaylovskiy deposit of the Kursk Magnetic Anomaly. I.P. Kalinin. pp. 203-218.
Linear (parting) weathered surface in nepheline syenites in the Khibiny Mountains. M.D. Dorfman. pp. 219-245.
Buried weathered surface of diabases and tuffites in the effusive-sedimentary horizon (D_2^2) of the southern Timan Ridge and its importance for the accumulation of iron and bauxite ores. V.A. Kaliuzhnyi. pp. 246-272.
Weathered surface of crystalline rocks in the Saltykov section of the Starooskol'skiy ore center of the Kursk Magnetic Anomaly. A.P. Nikitina. pp. 273-292.
Texture and composition of the film on quartz sand grains. A.M. TSekhomskii. pp. 293-312.
Silica content in natural waters and forms of its occurrence. I.I. Ginzburg, E.S. Kabanova. pp. 313-342.
Rapid petrographic identification of clay minerals using sections treated with water and ethylene glycol. I. Konta. pp. 343-350.
Solubility of Siliceous minerals in aqueous solutions. E.S. Kabanova. pp. 351-359.
Field determination of the adsorption capacity of clay rocks by the benzidine titration method. A.I. Makkaveeva, A.I. Pokrovskaia. pp. 360-364.
Determining the adsorption capacity of clays by adsorption of the methylene blue organic dye. L.I. Kul'chitskii. pp. 365-368.
Bibliography on weathered surface. E.A. Elisavetskaia. pp. 373-394.

Kristallografia. [Crystallography]. Vol. 5, no. 6, November-December, 1960.

Domain structure on crystals of an yttrium-iron garnet. V.D. Dylgerov, A.I. Drokin. pp. 945-950.
Growth of tourmaline under hydrothermal conditions. E.N. Emel'ianova, T.A. Zigareva. pp. 955-957.

Mor. flot. Morskoi flot [The Merchant Marine]. Vol. 20, no. 12, December 1960.

Sixth Soviet Antarctic Expedition. pp. 33.
Deep-sea sounding with recording device and electron beam tube. A. Astapov. pp. 43.

Neftianik [The Petroleum Worker]. Vol. 5, no. 12, December 1960.

Bitumen sampler. E. Sokolenko. pp. 22.
Shooting oil-field fluids sampler. E. Gref. pp. 32.

Prikl. geofiz. Prikladnaia geofizika [Applied Geophysics]. no. 27, 1960.

New method of determining the absorption coefficient of seismic waves. T.I. Oblogina. pp. 3-11.
Theory of geophone grouping. IU.V. Napalkov. pp. 12-34.
Plotting reflection horizons by the mean point method. O.K. Glovtov. pp. 35-49.
Accuracy of determining effective velocities from "derived" hodographs of reflected waves. E.A. Kozlov. pp. 50-56.
Determining mean velocities from data of the correlation refraction method for some regions of Western Siberia. N.A. Karaev. pp. 57-63.
Statistical method of working up observational data in the telluric current method. M.N. Berdichevskii, O.M. Raspopov. pp. 64-72.
Increasing the accuracy of determining the thickness of a sedimentary rock complex by making use of relationships governing measurements of the mean longitudinal resistivity Q_e. V.I. Formina. pp. 73-95.
Estimating the depth of the crystalline basement from magnetic and gravity anomaly computations. I.G. Klushin. pp. 96-115.
Magnetic anomaly interpretation in the Kursk Magnetic Anomaly by plotting ΔZ isolines in a vertical plane. V.N. Strakhov. pp. 116-130.
Computing the first and second vertical derivatives of gravity anomalies. O.A. Shvank. pp. 131-142.
Computation of the second vertical derivative from gravity anomalies and its use in determining abnormal masses. M.U. Sagitov. pp. 143-157.
Quantitative interpretation of electric logs in the transition zone. N.N. Sokhranov. pp. 158-170.
Determining the azimuth of a magnetized ball. V.N. Ponomarev, V.F. Zakharchenko. pp. 171-174.
Some problems concerning the apparatus used in lateral semielectrode logging. V.T. Chukin. pp. 175-200.
Use of the group method of neutron density distribution in investigating highly-absorbent rocks intersected by the borehole. E.M. Filippov. pp. 201-211.
Measuring the intensity of low-frequency alter-

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Terminology and symbols used in applied geophysics. V.N. Dakhnov and others. pp. 223-235.
Notation of values in applied geophysics. V.M. Zaporozhets. pp. 236-244.

Priroda [Nature]. Vol. 49, no. 12, December 1960.

Giant nummulities of the Crimea. B.F. Zernetskii. pp. 9.
The earth's crust in the Antarctic. G.E. Lazarev, S.A. Ushakov. pp. 17-22.
Natural heat. G.V. Kolpakov. pp. 23-25.
Natural salts of Kulunda. A.F. Kurakin. pp. 61-62.
Reef limestones. V.N. Nezimov, IU·V. Sementovskii. pp. 62-64.
Earthquake centers in Iran. S.A. Gorelikov. pp. 67-68.
Origin of the earth's magnetic field. E.G. Bullard. pp. 80-85.
Intrusions of southern Yakutia. P.P. Smolin. pp. 95-97.
Discovery of archaeopteryx remains. N.A. Gladkov. pp. 100-101.
Plack laccolith in the Crimea. N.N. Karlov. p. 107.

Probl. Arkt. i Antarkt. Problemy Arktiki i Antarktiki [Problems of the Arctic and the Antarctic]. no. 4, 1960.

Studies on the history of the Soviet North. M.I. Belov. pp. 7-14.
Soviet explorations in Antarctica. A.F. Treshnikov. pp. 15-25.
Development of geophysical research in the Arctic during the past 40 years. V.M. Driatskii and others. pp. 97-110.

Prom. stroi. Promyshlennoe stroitel'stvo [Industrial Construction]. Vol. 38, no. 12, 1960.

Constructing pile foundations on permafrost. IU.M. Goncharov. pp. 14-17.
All-Union conference on lowering construction costs and improving the quality of earthquake proof construction. A.L. Churaian. pp. 59-60.

Razved. i okh. nedr. Razvedka i okhrana nedr [Prospecting and Conservation of Mineral Resources]. Vol. 26, no. 1, January 1960.

Toward new labor achievements in 1960. pp. 1-4.
Copper potential of the eastern Udokan Range. M.E. Berdichevskaia, A.M. Leites. pp. 13-18.
Determining oil and gas ratio in rocks. A.A. Khanin. pp. 19-27.
Drilling wall core lifter and prospects for using it in test drilling. I.N. Sokolov. pp. 28-31.
Improving directional drilling methods. V.F. Pavlotskii, V.A. Petrov, A.V. Potapov. pp. 31-36.
Using the infinitely long cable method in aerial electric surveying. G.S. Fratov, N.M. Shuval-Sergeev. pp. 37-42.
Surveying for land drainage purposes from the point of view of engineering geology. E.G. Chapovskii. pp. 43-48.
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Aerotopographic method for controlling flight line in aerogeophysical surveying. V.F. Davydov. pp. 51-53.
Problems relative to the classification of mineral reserves. N.P. Grigor'eva. p. 60.

Razved. i prom. geofiz. Razvedochnaia i promyslovaia geofizika [Prospecting and Industrial Geophysics]. no. 35, 1960.

Conditions for the formation of points of return and closed loops in hodographs of reflected waves. T.N. Kulichikhina. pp. 3-12.
Choice of optimum conditions for explosions in marine seismic investigations by the refracted wave method. IU.P. Neprochnov. pp. 12-15.
Use of group explosions in Stalingrad Province. V.B. Leviant. pp. 15-23.
Some results of the use of group explosions within the outer zone of the Ciscarpathian downwarping. I.I. Kharaz, V.N. Boiko. pp. 24-29.
The intrinsic background and spectral sensitivity of discharge-type gamma counters. A.V. Zolotov, N.K. Kukharenko. pp. 29-34.
Certain factors influencing the puncturing capacity of bullet perforators. IU.N. Ter-Grigorian. pp. 35-41.
New scheme for a thyratron relay controlled by a magnetic sonde. L.L. Khurges. pp. 41-43.
Relation between the results of model studies over a step and the theoretical horizontal-vertical contact curves. E.I. Terekhin, A.S. Faradzhev. pp. 48-52.
Installation for the calibration of apparatus used in electric prospecting. L.S. Kochan. pp. 52-55.
Characteristics of different gravity derivatives with regard to the interpretation of gravimetric observations. O.A. Shvank. pp. 55-61.
Simplified determination of corrections for surface conditions in hodographs of reflected waves. M.M. Konovalov. pp. 61-65.
Field station for magnetic observations. V.M. Peliushenko. pp. 65-69.
Conversion of isonormals into isoverticals. V.A. Levi. pp. 69-73.
Conditions for seismic prospecting in the Fergana Valley. B.S. Vol'vovskii, I.S. Vol'vovskii, B.B. Tal'-Virskii. pp. 73-77.

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Use of theoretical hodographs in interpreting the materials of seismic prospecting in the area of the Pripet downwarping. L.S. Markuze. pp. 3-7.
Laboratory use of the controlled directional sensitivity method in interpreting the materials of deep seismic soundings. B.S. Vol'volskii, I.S. Vol'vovskii, V.Z. Riaboi. pp. 8-13.
Generation of transverse waves by directed explosions. B.L. Kaplan, V.V. Maiorov, pp. 14-23.
Propagation velocities of seismic waves in bottom deposits of rivers and surface layers of swamps. I.I. Bobrovnik. pp. 24-30.
Point method of interpreting vertical electric sounding curves. V.D. Kukuruza. pp. 31-39.
Some results of electric prospecting in investi-

gating the structure of the Baskunchak salt dome. G.N. Nazarov. pp. 40-44.

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Stek. i ker. Steklo i keramika [Glass and Ceramics]. Vol. 17, no. 11, November 1960.

Effect of the kaolinite dispersion on the technological properties of kaolin. V.N. Lednik. pp. 33-35.

Tekh. mol. Tekhnika - molodezhi [Technology for Youth]. Vol. 28, no. 11, 1960.

Wonder substance ("Book about petroleum" by A. Krasnov. Reviewed by K.V. Kostrin). p. 31.

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Transp. stroi. Transportnoe stroitel'stvo [Construction for the Transportation Industry]. Vol. 10, no. 12, December 1960.

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Determining the degree of fracturing of rocks in tunnel workings. I.N. Shubin. pp. 45-46.

Trudy GIN. Akademiia nauk SSSR. Geologicheskii institut. Trudy [Academy of Sciences of the U.S.S.R. Geological Institute. Transactions]. no. 26, 1960.

Subdivisions of the Quaternary system in the U.S.S.R. and foreign countries. V.I. Gromov. pp. 3-10.

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Trudy Inst. geog. Akademiia nauk SSSR. Institut geografii. Trudy [Academy of Sciences of the U.S.S.R. Institute of Geography. Transactions]. Vol. 75, 1959.

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Trudy MGRI. Moscow. Moskovskii geologorazvedochnyi institut. Trudy [Moscow Geological Prospecting Institute. Transactions]. Vol. 34, 1959.

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Trudy VGU. Voronezh. Universitet. [University. Transactions]. Vol. 50, 1959.

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Trudy VNIGNI. Moscow. Vsesoiuznyi nauchno-issledovatel'skii geologorazvedochnyi neftianoi institut. Trudy [All-Union Scientific Research Institute of Petroleum Geology and Prospecting. Transactions]. no. 19, 1959.

Stratigraphy of Bavly sediments in the Volga-Ural region. Z. P. Ivanova, A. A. Klevtsova, M. M. Veselovskaia. pp. 7-23.
Stratigraphy of old sediments in western Bashkiria and correlation with their equivalents in other regions of the Russian Platform and the Urals. K. R. Timergazin. pp. 24-44.
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Ugol' Ukr. Ugol' Ukrainy [Coal of the Ukraine]. vol. 4, no. 11, November 1960.

Role of rock pressure in the distribution of sudden outburst areas in longwall mining of steeply pitching Donets Basin Seams. N. G. Rusakov. pp. 4-6.

Usp. khim. Uspekhi khimii [Progress in Chemistry]. vol. 29, no. 12, December, 1960.

Presence of transuranium elements in nature. R. TSaletka, A. V. Lapitskii. pp. 1487-1497.

Vest. AN SSSR. Akademiia nuak SSSR. Vestnik [Academy of Science of the U. S. S. R. Journal]. vol. 30, no. 12, December, 1960.

New information on the Tunguska meteorite. V. G. Fesenkov, E. L. Krinov. pp. 32-35.
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"Principles of geocryology (permafrost studies)." Reviewed by N. I. Tolstikhin. pp. 124-126.

Vop. ekon. stat. Voprosy ekonomicheskoi statistiki [Problems of Economic Statistics]. No. 12, December, 1960.

From the practice of communist labor collectives. E. Razumov. pp. 134-138.

Zap. LGI. Leningrad. Gornyi institut. Zapiski [Institute of Mining, Records]. vol. 36, no. 2, 1959.

Some speriferids from Namurian sediments of the eastern slope of the Urals. S. N. Guseva. pp. 3-14.
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RECENT TRANSLATIONS IN GEOLOGY

A review of the Translation Services

This part of the Reference Section is devoted each month to a listing of the new translations of geologic significance which have become available from sources other than IGR and the established cover-to-cover journals in geology. This is done to accomplish several purposes: 1) inform geologists of the foreign literature in their field available in translation; 2) provide information necessary to avoid duplication of translation effort, and 3) advise geologists of the activities of the various organizations providing translations or related services in their field.

GEOLOGIC TRANSLATION JOURNALS

The following journals regularly contain translations of interest to geologists. Therefore, the subsequent list of recent translations does not include articles falling within the scope of the cover-to-cover programs of these journals:

Atomic Energy, published by Consultants Bureau.

Bulletin (Izvestiya) of the Academy of Sciences U. S. S. R., Geophysics Series, published by the American Geophysical Union.

Doklady of the Academy of Sciences of the U. S. S. R., Earth Sciences Sections, (Geochemistry, geology geophysics, hydrogeology, mineralogy, paleontology, petrography, lithology and permafrost), published by the American Geological Institute.

Geochemistry, published by the Geochemical Society.

Geodesy and Cartography, published by the American Geophysical Union.

Izvestiya of the Academy of Sciences of the U. S. S. R., Geologic Series, published by the American Geological Institute.

Petroleum Geology, published by the Review of Russian Geology.

Problems of the North, published by the National Research Council of Canada.

Soil Science, published by the American Institute of Biological Sciences.

Soviet Geography, selected translations and reviews published by the American Geographic Society.

Soviet Physics: Crystallography, published by the American Institute of Physics.

SOURCES OF TRANSLATIONS

The current list of recent translations is from the following:

Technical Translations, vol. 6, nos. 1 and 2.

Atomic Energy Commission Translation List nos. 55, 56, and 57.

Consultants Bureau, special listings,

Petroleum Geology Magazine, special listings,

American Geological Institute, Translations Office.

An index of sources and addresses will be found at the end of the list of translations.

RECENT TRANSLATIONS

Akhmanov, M. V., 1959, Spectres infrarouge d'absorption des mineraux: transl. in French of Uspekhi khim (U. S. S. R.), v. 28, no. 3, pp. 312-335. CEA Trans. no. R-985. OTS or SLA 61-15802. $7.60.

Ankinovich, Ye. A., 1960, A new vanadium mineral — rusacovite: Vses. Mineralog. ob-va, Zapiski (U. S. S. R.), v. 89, no. 4, pp. 440-447. JPRS: 9330. OTS or SLA 61-23016. $1.60.

Arkhangel'skiy, M. M., Dzhincharadze, D. I., and Kuris'ko, A. S., 1960, Calculation of tunnel linings: Transzheldorizdat, Moscow, 344 pp., 3,000 copies printed. Book review, 4 pp., LC or SLA, BR-SOV/4903. ph $1.10.

Baranskiy, L. N., and Naumensokov, N. L., 1960, Observations of earth currents at Mirnyy and Oazis stations during 1957: Sovet. Antark. ekspeditisya. Inform. byull., no. 14, pp. 24-28. JPRS: 8192. OTS 61-21584. $0.50.

Bulanzhe, Yu. D., 1960, General assembly of the International Geodetic and Geophysical Union: Vestnik, Aka. nauk SSSR, v. 30, no. 11; in Herald of the Academy of Science of the U. S. S. R. vol. 30, no. 11, selected articles. JPRS:4506. OTS 61-21528. $3.50 complete journal.

Domarev, V. C. [V. S. ?], 1956, Some geological features of metamorphic ore deposits: Vses. geol. inst., Materialy: polez. iskopayemyye (U. S. S. R.) no. 8, pp. 7-41. OTS or SLA 61-19218. $3.60.

Dzhabarova, Kh. S., 1960, Some data on the flora of middle Sarmatian deposits in the Astrakhanbazar region (Azerbaidzhan): Dokl. AN SSSR, v. 134, no. 5, pp. 1166-1168. ATS-21N50R. $6.00.

Faddeyeva, I. Z., 1960, Megaspores from the Jurassic of Western Kazakhstan: Paleontol. zhur. (U. S. S. R.), no. 4, pp. 125-128. ATS-20N50R. $7.00.

Fedynskiy, V. V., 1960, Meteors: trans. of monogr. Astronomiya v SSSR za Sorok Let 1917-57 [Astronomy in the U. S. S. R. over 40 years 1917-57], Moscow, pp. 175-185. JPRS: 4576. OTS 61-21576. $0.50.

______________, 1960, Selected works of G. A. Gamburtsev [seismologist]: Vestnik, Akad. nauk SSSR, v. 20, no. 11. In, Herald of the Academy of Science of the U. S. S. R., vol. 30, no. 11, selected articles. JPRS: 4506. OTS 61-21528. $3.50 complete journal.

Fridland, V. M., 1960, The first soil map of the Democractic Republic of Vietnam: Vestnik, Akad. nauk SSSR, v. 30, no. 11. In, Herald of the Academy of Science of the U. S. S. R., vol. 20, no. 11, selected articles. JPRS: 4506. OTS 61-21528. $3.50 complete journal.

Gerasimov, I. P., 1945, A soil map of the world

and the general laws of soil geography: Pochvovedeniye (U. S. S. R.), no. 3-4, pp. 152-161. PL-480. OTS 60-21850. $0.50.

erling, E. K., 1957, The migration of helium from minerals and rocks: in Trudy Rad. inst., im. V.G. Khlopin, v. 6, pp. 64-87. Trans of complete journal available from OTS as AEC-tr-4208. $2.75.

inzburg, A. I., 1957, Bityite-lithium-beryllium margarite: Akad. nauk SSSR Mineralog. muzey. Trudy, v. 8, pp. 128-131. OTS or SLA 61-19236. $1.10.

orbunova, Z. N., 1960, Composition of the clay minerals in various horizons of the sediments of the Indian Ocean: Dokl., AN SSSR, ser. okeanol., v. 134, no. 5, pp. 1201-1203. PG, spec. tr. no. 2. $2.00

__________, 1960, Highly dispersed minerals in the sediments of the Indian Ocean: Dokl., AN SSSR, ser. okeanol., v. 134, no. 4, p. 535-538, PG, spec. tr. no. 1, $2.

ankin, B. N., n. d., The microstructure and macrostructure of elastic waves in one-dimensional continuous nonhomogeneous media: Trudy No. 39, Geofiz. inst., Akad. nauk SSSR. Translation by American Geophysical Union with CB. 120 pp. $6.00.

aplan, G. Ye., et al., 1960, Thorium, its raw material resources, chemistry and technology: Book review of Toriya, ego syr'yevye resursy, khimiya i tekhnologiya, publ. by Atomizdat, Moscow, 223 pp., 4,000 copies printed. 3 pp. OTS BR-SOV/5017. $1.10.

ašpar, Jan, 1959, The minerals of the radioactive elements, their origin and development. SNTL, Prague, 155 pp., 2,700 copies printed. Review, 2 pp. LC or SLA, BR-CZECH/4900. ph $1.10.

irichenko, A. N., 1956, Fauna of Binagady Kirbearing strata; true Hemiptera: Akad. nauk Azer. SSR, Baku. Dokl., v. 12, no. 8, pp. 563-564. OTS or SLA 61-14370. $1.10.

ononova M. M., 1956, The humus of the main types of soil of the U. S. S. R.; its nature and mode of formation: trans. of monogr. Gumus glavneyshikh tipov pochv SSSR, yego priroda i puti obrazovaniya, presented at All-Union Meeting of Soil Scientists, Moscow, 28 Jan-4 Feb. RTS 1818. OTS or SLA 61-19800. $1.60.

ravtsov, Ya. M., and Futergendler, S. I., 1960, Certain data on diamonds found in form of polycrystalline aggregates: Vses. mineralog. ob-vo. Zapiski (U. S. S. R.), v. 89, no. 4, pp. 464-466. JPRS: 9331. OTS or SLA 61-23017. $1.10.

abuntsov, A. N., 1957, Concerning the crystallography of epididymite: Akad. nauk SSSR. Mineralog. muzey, Trudy, v. 8, pp. 164-167. OTS or SLA 61-19239. $1.10.

ebedev, V. I., 1959, Sur les causes de l'oxydation de l'uranium dans les uraninites: Zap. Vses. mineralog. ob-va., v. 88, pp. 667-671 (Trans. in French). CEA-tr-R-1253.

Lobova, Ye. V., and Petrov, B. F., 1945, The soil-geographical regions of Western China: Pochvovedeniye (U. S. S. R.), no. 3/4, pp. 189-198. PL-480. OTS 60-21854. $0.50.

Nimidoff, D. A., 1960, Underground explosions, plutonium and nuclear arms: Forces Aerienne Francaises (France), pp. 45-66. SLA UCRL-Trans-644(1). $1.16 mi or $3.60 ph.

Oliferov, A. N., 1960, Protection of soils from erosion in People's China: Vest. sel'skokhoz. nauki (U. S. S. R.), v. 5, no. 11, pp. 143-148. OTS or SLA 61-19750 (trans. A-1256). $1.60.

Parfenova, Ye. I., and Yarilova, Ye. A., 1956, Formation of secondary minerals in soils and plants in connection with the migration of elements: Pochvovedeniye (U. S. S. R.), no. 4, pp. 36-42. PL-480. OTS 60-21838. $0.50.

Patrovský, Věnceslav, 1960, Analytical Chemistry of rare elements: Book review of Analiticheskaya khimiya redkik elementov, Gosgeoltekhizdat, Moscow, 175 pp., 3,000 copies printed [Trans. of "Analytická chemie vzácných prvků"]. 6 pp. OTS BR-SOV/4759. $1.10.

Petrusevich, M. N., and Nazik, L. I., 1955, Colored aerophoto-surveys in geological mapping: Sovetskaya geologiya (U. S. S. R.), no. 42, pp. 156-163. OTS or SLA 61-13417. $1.10.

Prasolov, L. I., and Petrov, B. F., 1944, Soils of Western Europe from the viewpoint of the Russian School of Pedology: Pochvovedeniye (U. S. S. R.), no. 9, pp. 393-409. PL-480. OTS 60-21852. $0.50.

Rybakova, N. O., 1960, The change in morphological characteristics of spores of some species of ferns during their development process: Izv. Vyss. ucheb. zaved., geol. i razed. (U. S. S. R.), v. 3, no. 5, pp. 61-66. ATS-37N5OR. $10.50.

Sadovskiy, M. A., 1945, Experimental research on the mechanical action of the shock wave of an explosion: Akad. nauk SSSR. Seismolog. inst., Trudy, v. 116, pp. 1-44. JPRS; 7354. OTS 61-11995. $2.50.

Safronov, B. G., Aseyev, G. G., et al., 1960, Propagation of successive shock waves: Physics and eng. inst., Akad. nauk URSR, Khar'kov, pp. 68-88. Sandia Corp. trans. AEC OTI 6041.

Sappa, Mercurino, 1954, View of the search for "endogenous power" in various regions of the world during the last thirty years: Annali di Geofisica (Italy), v. 7, no. 1, pp. 451-462. SLA 59-18608. $2.60

Sarsadskikh, N. N., and Rovsha, V. S., 1960, Genetic conditions of the diamond mineral-satellites in the kimberlites of Yakutia: Vses. mineralog. ob-vo. Zapiski (U. S. S. R.), v. 89, no. 4, pp. 392-399. JPRS: 9329. OTS or SLA 61-23000. $1.60.

Shchepot'eva, E. S., 1957, On the conditions of formation of natural radium-bearing waters: Trudy Rad. inst., im. V. G. Khlopina, v. 6, Trans. of complete journal available OTS as AEC-tr-4208. pp. 41-54. $2.75.

Skornyakova, N. S., 1960, Manganese concretions in sediments of the northeast part of the Pacific Ocean: Dokl., AN SSSR, ser. okeanol., v. 130, no. 3, pp. 653-656. PG, spec. tr. no. 3. $2.00.

Starik, I. E., and Melokova, O. S., 1959, Factors influencing the emanating power of artificial salts and minerals on particle size for radion, thoron and actinon: Radiokhimiya, v. 1, pp. 196-203. LC or SLA AEC-tr-4555. mi or ph, $1.80.

Starik, E. I., and Polevaya, N. I., 1957, The leachability of ThX and RdTh from minerals: in Trudy Rad. inst., im. V. G. Khlopin, v. 6. Trans. of complete journal avail. from OTS as AEC-tr-4208. pp. 104-118. $2.75.

Tseng, Yung-sheng, K'an, Yung-chu, et al, 1960, Low frequency seismic work in Tsaidam basin: K'o Hsueh T'ung Pao (Chinese People's Republic), no. 10, pp. 313-316. JPRS: 5706. OTS or SLA 60-41496. $1.60.

Vershkovskaya, O. V., Krasnova, V. S., and Saltykova, V. S., 1960, Gallium: research methods, occurrences, in rock formations and minerals, types of deposits: IZd-vo AN SSSR, 145 pp., 4,000 copies printed. Book review, 3 pp., LC or SLA, BR-SOV/4908. ph $1.10.

Vesenkov, V. G., and Krinov, Ye. L., 1960, New data concerning the Tungusky meteorite: Vestnik Akad. nauk SSSR, v. 30, no. 12, pp. 32-35. OTS or SLA 61-14986. $1.10.

Vilenskiy, D. G., 1957, Soil Science, 3d ed.: trans. of monogr. Pochvovedeniye, 3d ed., Moscow, 456 pp. PL-480. OTS 60-51197. $5.00.

Vinogradov, P. A., 1960, New experimental data relative to the vertical component of short-period variations of the field of earth currents: Geol. i geofiz. (U. S. S. R.), no. 8, pp. 100-105. JPRS: 8080. OTS 61-21666. $0.50.

Vladimirova, M. E., 1957, Determining the age of minerals found in the Ilmen Mountains on the basis of radioactivity data: In Trudy Rad. Inst., im. V. G. Khlopin, v. g, pp. 136-166. Trans. of complete volume available from OTS as AEC-tr-4208. $2.75.

Vorobkov, L. N., Gavrilko, V. M., Lobachev, P. V., and Shestakov, V. M., 1960, Lowering the water table in hydrotechnical construction: Gosstroyizdat, Moscow, 243 pp. 4,000 copies printed. Book review, 4 pp. LC or SLA, BR-SOV/4912. ph $1.1(

Wanke, H., and Konig, H., 1959, Age determination on stone meteorites with the potassium-argon method using a newly developed technique: Max-Planck Institut fur Chemie, Mainz. AFCRL-TR-60-411. AEC OTI. (Also published in Z. Naturforsch., 14a, pp. 860-866; 13a, pp. 645-649, and 16a, pp. 127-131).

Wendt, Immo, 1960, The application of radioisotopes in practical geology: Kerntechnik, (Germany), v. 2, no. 1, pp. 1-9. AEC OTI 6077.

Zauer, V. V., 1960, The Late Permian flora of the Solikamsk area: Paleontol. zhur. (U. S. S. R.), no. 4, pp. 114-124. ATS-19N50R. $19.95.

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LC	Photoduplication Service Publication Board Project Library of Congress Washington 25, D. C.
ATS	Associated Technical Services, Inc. P. O. Box 271 East Orange, N. J.
SLA	Special Libraries Association Translations Center The John Crerar Library 86 East Randolph Street Chicago 1, Illinois
OTS	Office of Technical Services U. S. Department of Commerce Washington 25, D. C.
CB	Consultants Bureau Enterprises, Inc. 227 West 17th Street New York 11, New York
CEA	Commissariat a l'Energie atomique S. A. R. L. DUNOD 92, Rue Bonaparte Paris (6e), France